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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 289
Distortion of Railway Track by the Indian Earthquake of June, 1897 (illustrated)..... 290
A Military Survey Made with a Bicycle..... 290
Sewage Pumping Machinery at Budapest, Hungary (with two-page plate and other illustrations).... 290
A Diagram for Determining the Size of Beams of Rectangular Cross-Section (illustrated).... 292
Experience with Hoadley-Knight Air Motor Cars in Washington, D. C..... 292
The Computation of Strains in Coal and Grain Bins (illustrated)..... 293
Experience with Electric Traction on the New York, New Haven & Hartford R. R..... 299
The Frequency of Tornadoes in Various Parts of the United States..... 300
The Disposal of Garbage and Refuse 301
Railway Bridge Floors (illustrated)..... 302
Annual Meeting of the American Public Health Association 304
EDITORIAL NOTES. 296
Experience with Third Rail Traction on the New York, New Haven & Hartford R. R.—The High-Speed Record of the Philadelphia and Atlantic City Express on the Philadelphia & Reading Ry.—The Tenure of Office of Superintendent of Water Works under Municipal Ownership and under Private Ownership.
EDITORIAL:
Efficiency of a Four-Stage Air Compressor Delivering Air to a Storage Reservoir.....
LETTERS TO THE EDITOR 297
A Suggestion for Expansion Bearings for Bridges (illustrated)—A Large Concrete Bell Mouth Inlet—The Tropenas Process of Steel Making.

AN UNDERGROUND RAILWAY CONSTRUCTION COMPANY has been incorporated to bid for the franchise of the New York rapid transit railway, providing the Circuit Court commission, which has been examining the plans of the Rapid Transit Commission, reports upon them favorably. Mr. Charles Sooysmith, M. Am. Soc. C. E., of the firm of Sooysmith & Co., of New York, is authority for the statement that this company has been incorporated, and although he declines to give the names of the people behind the plan, he asserts that they are fully capable financially and are ready to push the work actively should they secure the franchise. It is stated that the Rapid Transit Commission is ready to advertise for bids for the franchise as soon as the courts decide favorably upon its plans. Under the law the franchise must be sold to the highest bidder.

AMERICAN EXPORTS OF STEEL RAILS have attracted a good deal of attention of late, but it is well to remember that we have only made a beginning in securing our share of foreign trade. In the month of September exports of steel rails from Great Britain amounted to 36,214 tons, which was an increase of some 2,000 tons over the shipments of September, 1896.

THE SALE OF THE UNION PACIFIC RY. to the reorganization committee took place Nov. 1, 1897. The road was sold under a mortgage held on the property by the United States Government. The sum bid by the reorganization committee was $39,883,281 for the property itself and $13,645,250 for the bonds held in the sinking fund. In addition to these bonds, the sinking fund holds $4,036,400 in cash, which reverts to the Government, and which makes the total amount paid the Government $57,564,932. Under the terms of the sale, the purchasers have 90 days in which to pay the full amount of the purchase money.

A NEW YORK-CHICAGO LIMITED TRAIN, consisting of seven cars, has just been turned out of the shops of the Wagner Palace Car Co., and will shortly be put in operation by the New York Central & Hudson River R. R. The train will make the trip between Chicago and New York in 24 hours, and will be known as the New Lake Shore Limited. It consists of a buffet smoking car, a dining car, a drawing room car, three sleeping cars and a compartment observation car. The cars are connected by wide vestibules, and have Pintsch gas ceiling lights and electric berth lights, the electric lighting system adopted being the Gibbs. The baggage room of the buffet smoking car contains the 30-HP. Westinghouse engine and dynamo for electric lighting. The train is luxuriously equipped throughout, having bath, barber shop, library, waiting room, stenographers' and typewriters' service, the latter being free, besides the usual conveniences and comforts of the regular Wagner car service. Perhaps the most distinctive features of the train as a whole are the provisions made for persons or parties desiring to travel as privately as possible, there being private staterooms, private dining rooms, etc., with separate washrooms and toilet conveniences. In the interior the cars exhibit a variety of styles of decoration, but on the outside all are alike, being the regular Wagner palace car color, sparingly decorated with gold leaf.

ANOTHER THIRD RAIL EXPERIMENT on a steam railway is being conducted, this time by the St. Louis, Kansas City & Colorado Ry., near St. Louis. The test, which is intended to determine the merits of a system developed by Mr. B. C. Seaton, of St. Louis, includes the equipment of a half-mile of standard track near Forsyth Junction with the third rail and the operation of trains upon the section. Should the claims of the inventor prove true it is stated that the St. Louis, Kansas City & Colorado Ry. will at once equip all its suburban lines with the system.

A NEW APPLICATION OF ELECTROLYSIS is the formation of metal frames about prismatic glass used for windows. In the process the glass sections are mounted in frames of the desired shape formed of thin ribbons or wires and submerged in a bath. A suitable anode is placed in the tank and current is turned on. Metal is deposited until a complete frame is formed, firmly binding the glass in place.

AN ELECTRICAL WATER-POWER EQUIPMENT is at present employed by the British Daijeeling Tea Co., India, to operate all the machinery necessary to handle the growth of 3,000 acres of tea land. The generating plant takes water from the Rungbong River by means of a masonry canal at a point where a fall of 50 ft. could be obtained. Here also a 40 HP. Jouval turbine was installed and belted to a 30 HP., 320-volt, 70 ampere Manchester direct current generator. The transmission line extends back from the river about a mile to the factory, where a 24 HP. Manchester motor operates 2 tea driers, 2 tea leaf rollers, 1 tea packer, 2 tea sifters, 1 tea cutter. Current is also used to light the building. The plant is found to perform the work most satisfactorily and far more economically than steam, owing to its cleanliness and safety, and the abundant supply of water.

THE MOST SERIOUS RAILWAY ACCIDENT of the week happened Nov. 2 on the Sedalia, Warsaw & Southwestern R. R., about three miles north of Warsaw, Mo. A mixed train was derailed and rolled down a 40-ft. embankment, killing the engineer and badly injuring three trainmen and one passenger.

A SERIOUS RAILWAY COLLISION is reported on Nov. 1, at Ellenburg, on the Halle Kottbus Line, 15 miles from Leipsic, Germany, in which 20 persons were injured, of which number six will die.

AN ACCIDENT illustrating the need of some form of block signal occurred Oct. 28, on the Lehigh Valley R. R., 1½ miles from the South Plainfield station. From reports it appears that a fast milk train ran into the rear of a 50-car coal train which was running slowly at the time. The engine of the milk train jumped the track and turned over on the west bound track. Hardly had the engine come to rest when an express train composed of six express cars and a Pullman sleeper crashed into the wrecked engine, which was thrown to the side of the track. Singularly enough the fireman of the milk train seems to have been the only one hurt in any way, and his injuries are said not to be serious.

THE $12,000,000 LOAN BILL IN PHILADELPHIA is reported as having been carried at the city election on Nov. 2 by a small majority. The main purposes of the loan are as follows: $3,700,000 for extension, improvement and filtration of the water supply; $2,000,000 for pavements; $1,000,000 for improvements to the gas works; $1,000,000 for a public library site and building; $900,000 for abolishing grade crossings on the Philadelphia & Trenton R. R.; $600,000 for bridges, and $500,000 for sewers. A number of ordinances providing for a new or a filtered water supply are now before councils and an ordinance providing for the lease of the gas works to the United Gas Improvement Co. has been recommended by the Joint Committee on Finance and Gas, composed of members of both branches.

THE NEW MUNICIPAL ELECTRIC LIGHT AND power station in Bradford, England, was formally opened last month. The station was begun in 1896, and has cost, with its equipment, about $200,000.

A FIVE-YEAR GARBAGE CONTRACT AT CHICAGO has been awarded to Mr. A. J. Murphy, of that city, for $250,270 a year. The contract includes the collection and final disposal of the garbage, ashes and other refuse of the city, with the exception that garbage proper need not be removed from hotels, restaurants, and commission houses, although the contractor must dispose of such garbage if hauled to his receiving stations; and with the further exception of dead animals, manure and ashes from manufacturing establishments and office buildings. The specifications provide that the garbage must be burned or treated by some reduction process. It is reported that the English type of garbage furnaces or "refuse destructors," with provision for utilizing the heat, will be put in, similar to those recently installed for the Shoreditch vestry of London, England. The Shoreditch plant was briefly described in Engineering News of Aug. 26, 1897, and in the same issue there was an editorial discussion of the utilization of heat from garbage furnaces.

THE LEGALITY OF THE USE OF WATER METERS at Lancaster, Pa., has been established by a court decision.

A LAKES AND GULF WATERWAY from Chicago by way of the Chicago Drainage Canal and the Des Plaines, Illinois and Mississippi Rivers to the Gulf of Mexico is urged in a series of resolutions passed by a convention of delegates from the Illinois River towns, held at Beardstown, Ill., on Oct. 21. The resolutions urge first that the U. S. government shall remove the four dams built in the Illinois River to provide slack water navigation, since under the present conditions these dams cause the overflow of large areas of the bottom lands along the river, and cause the farmers a heavy expense for drainage, levees, etc. Secondly, the resolutions urge the construction by the U. S. government of the deep waterway. There are now four dams in the Illinois River, located at Henry, Copperas Creek, Lagrange and Kampville, and they are 6½ ft., 6 ft., 8 ft. and 7 ft. high, respectively. These dams provide slack water navigation for about 130 miles of the river and cost about $2,000,000 to construct. It is stated that Congressman W. H. Henrichson, of Chicago, will introduce a bill at the coming session of Congress which will embody the provisions urged by the resolutions of the Beardstown convention.

PAINTING GAS HOLDERS BY A COMPRESSED AIR spray has recently been tried by the Turner Machine Co., of New York, N. Y., with complete success and it is stated with considerable economy over painting by hand. The painting was done on the gas holders of the Equitable Gas Co., of New York, which are located at 40th St. and Ave. A. In doing the painting the holders were first lowered and the top and three 2-ft. sheets of the sides were painted, working from the ground. The holder was then gradually raised as the painting of the sides progressed. Owing to the necessity of using the tanks for storage it is stated that the work was frequently interrupted and there was only one day during which the work progressed steadily. On this day the top and 18 sheets of the sides were painted on a holder 90 × 90 ft. and 24 sheets high. The work was carried on from 9:50 a. m. to 5 p. m. and the area painted was between 16,000 and 17,000 sq. ft. Three men using two sprays did the work at a cost for labor of $6.25, or less than ½ ct. per sq. yd. About the same amount of paint was used as would have been the case in painting by hand. A man with a brush can paint only from 1,200 to 1,500 sq. ft. per day.

GAS EXPLODED IN A SEWER in Providence, R. I., on Sabine St., Oct. 25, throwing several manhole covers high in the air and doing considerable damage in houses on the street. The leaking gas is alleged to have been due to injury to the gas main by the heavy roller used in macadamizing the street. The explosive mixture of gas and air in the sewer and manholes was probably ignited by laborers, who were using a flame in searching for the leaks.

A WIRE ROPE TRAMWAY across the Chilkoot Pass will be constructed by the Chilkoot R. R. & Transport Co., of Tacoma, Wash. The contract for this tramway has been awarded to the Trenton Iron Co., of Trenton, N. J., and it will be built on the Bleichert system. It is stated by the contractors that the line will run from Sheep Camp to Crater Lake, a distance of about 3½ miles, making one bend of 153°. The highest elevation, 2,600 ft. above Sheep Camp, is reached at a point within 2,000 ft. of the discharge terminal at Crater Lake, the fall from here to the lake being 500 ft. The line will be used for the transportation of merchandise, ore and passengers, and will form part of a general line of transportation for reaching the Klondike by way of Dyea and Lake Lindermann. From Dyea to Sheep Camp, a distance of about 4 miles, it is proposed to lay a surface road, and from there on through the pass the transportation will be effected by the wire rope tramway, although the entire distance may eventually be covered by a wire rope tramway, this matter being now under consideration. The tramway is to have a capacity of five tons per hour, and it is expected that the line will be completed and ready to run by the middle of January, 1898.

A CUBICAL CONCRETE MIXER, having a hollow shaft perforated with holes inside the box or mixer and provided at the trunnion with a union which connects by piping with a water tank, has been put on the market by Thomas Carlin's Sons, of Allegheny, Pa. The idea, of course, is to apply the water to the mixture after the cement, sand and stone have been mixed dry by the mixer and without stopping the machine. By suitably arranging the tank and valves just the proper proportion of water for the batch of material being mixed can be applied. These mixers can be mounted and operated in any convenient manner, like any mixer of the cubical or box type.

DISTORTION OF RAILWAY TRACK BY THE INDIAN EARTHQUAKE OF JUNE, 1897.

In our issues of Jan. 9 and Aug. 25, 1892, we published views showing the destruction of railway track and bridge structures by the great Japanese earthquake of Oct. 28, 1891. The earthquake, which occurred throughout northern and eastern India in June last, seems to have been fully as disastrous to both the track and bridges of the Indian railway lines, and in the accompanying engravings reproduced from the "Indian and Eastern Engineer" are shown a number of examples of the damage wrought to railway property by this widely felt seismic shock. Fig. 1 is a view of the wrecked Munshai Bridge, on the Cooch Behar State Ry., of 2 ft. 6 in. gage, which is operated by the Eastern Bengal State Ry., and Fig. 2 shows the peculiar distortion of a section of track on the Cooch Behar State Ry., between Haldibari and Moghai Hat.

Fig. 1.—Munshai Bridge on the Cooch Behar State Ry.

Fig. 2.—Distortion of Railway Track on Cooch Behar State Ry.

RESULTS OF THE EARTHQUAKE OF JUNE, 1897, ON THE STATE RAILWAYS OF INDIA.

According to the report of Mr. R. D. Oldham, Superintendent of the Geological Survey of India, on the earthquake, the shock was felt over an area of nearly 1,000 × 1,500 miles. The area over which the shock was destructive was considerably smaller, but was also large, extending from Calcutta to Jorhat, east and west. All masonry buildings in the destructive area have, it is stated, been leveled to the ground, not by overthrow, but by a shattering of the walls into fragments, on the top of which the roof subsided. According to the records of the seismometer at Shillong, it is calculated that the violence of the shock was equal to a backward and forward shake of 7 ins., repeated 60 times a minute. It is not difficult to understand that few structures should have been able to withstand this rocking.

Minor evidences tending to show the violence of the movement are said to be numerous. In many places the masonry boundary pillars have been shaken into pieces, and, what is more strange, heaps of broken stone road metal were scattered out in layers only a few inches deep. The drainage channels, tanks and wells were filled up over large areas. It is stated that this resulted not merely from the shaking in of the sides, but from the actual forcing up of the bottoms, as is also shown by the effect on bridge piers, many of which have been raised bodily upward. The effect of the shock upon the alinement of the track supported by an alluvial soil, which is shown by Fig. 2 is, to an engineer at least, a most impressive illustration of the magnitude of the forces at work in the earthquake shock. The shaking down of a tall masonry bridge pier or of a building wall is a result to be expected, but the maintenance-of-way engineer who wakes up in the morning to find that the stone ballasted track and roadbed, which he regarded as being as stable and solid as mother earth itself, has taken on the sinuosities of a lively snake, is more than likely to have his faith in the permanency of mundane things rudely shaken, besides undergoing other very natural but unpleasant emotional states.

A MILITARY SURVEY MADE WITH A BICYCLE.

During the recent service of the Third Brigade of the Pennsylvania State Militia in the vicinity of Hazleton, Pa., on account of troubles with the striking coal miners, Gen. Gobin, the commanding officer, detailed Lieut. Frederic A. Snyder, of the 12th Regiment, Asst. City Engineer of Williamsport, Pa., to prepare a map showing the roads and topography in the vicinity of Hazleton, for the use of the officers commanding the troops. Sergeant Geo. D. Snyder, of the same regiment, Assoc. M. Am. Soc. C. E., and City Engineer of Williamsport, was detailed as assistant on the work. We quote as follows from the report submitted to Gen. Gobin upon the completion of the work:

As I had no definite knowledge of our probable length of service in the vicinity of Hazleton, I did not wish to undertake an elaborate survey of the territory occupied by the troops, which I might not be able to complete, before the tour of duty was ended; for this reason I decided to make a road map, of the territory occupied, connecting all the camps and other strategic points.

For this purpose I adopted rapid road sketching methods, using a bicycle with cyclometer registering revolutions to obtain distances, and a military pocket compass for directions. In this way I was able, with one assistant, to survey 46.22 miles of roads and paths in 19 hours and 4 minutes of actual time, attending to my regular duties as well. The whole period of the survey occupied about seven days. The map was worked up and plotted from my notes, by my assistant, at the end of each day's work, so if necessary a hasty sketch of each road surveyed could have been furnished on the day of the work.

The elevations were derived from barometric levels, using as a base Bench Marks, giving mean sea elevations, furnished by Mr. Celiax, City Engineer of Hazleton, which were also checked by contours, indicated on the maps of the U. S. Geological Survey.

I would call your attention to the great value of the bicycle in making reconnaissance of roads, and making road maps. It not only gives a rapid and accurate means of determining distances, but by its aid the topographer can rapidly transport himself over the large areas he necessarily must cover in his work. In the survey for the accompanying map about half of the work was done in the rain, and even under these adverse conditions the bicycle proved much more efficient than any other means.

From the copy of the map accompanying the report we learn that the map was plotted by coordinates from the results of the survey, the coordinates being calculated with a 10-in. Manheim slide rule. The error of closure was from 1½% to 4%.

The accuracy and usefulness of a bicycle fitted with a cyclometer for measuring distances on roads is something which many engineers have noted; but the above is the most extensive use in actual surveying of which we have heard. We believe, however, that a three-wheeled machine, geared very low, and designed to be propelled by one man, while the topographer sits on a seat between the two rear wheels, would have many advantages over the bicycle for such work as that described above. With a stout-legged private to propel the machine, the topographer could work twice or thrice as rapidly as he could with a bicycle. He could make his records of courses, distances, elevations, etc., as the machine moved along, and could stop and make detours on foot to points on either side of the road commanding a more extended view with comparatively little delay. We see no reason why such a machine as we have outlined should not form part of the equipment of the topographical staff of every considerable body of troops.

SEWAGE PUMPING MACHINERY AT BUDAPEST, HUNGARY.*

(With two-page plate.)

After a great deal of preparatory work had been done construction was commenced in 1891 upon a sewerage system for that part of the city of Budapest, Hungary, which is situated on the left side of the Danube River. At a low stage of the river the sewer outlets are above the water level, and the sewage flows freely, but at mean and high tides it must be pumped. The specifications required that a flow of 1.8 cu. m. (476 gals.) per sec., estimated for an ordinary dry period, should be raised to and discharged at a height of 5 m. (16.4 ft.); this height corresponding to the head at high water. A provision was also made for the regular use of the sewage in fertilizing fields, and for this purpose it had to be pumped by suitable machinery to a height of 16 m. (52.5 ft.), and carried to a distance of 3,000 m. (9,842.7 ft.). In order to provide for local rain storms, which are quite fre-

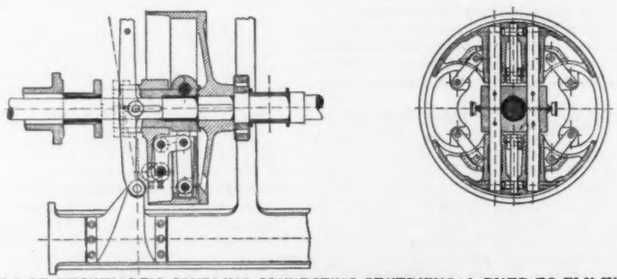


FIG. 9.—DETAILS OF HECHWART'S COUPLING CONNECTING CENTRIFUGAL PUMP TO FLY WHEEL SHAFT, BUDAPEST SEWAGE PUMPING STATION.

* Abstracted from an article by O. N. Mueller, Jr., in "Zeitschrift des Vereines Deutscher Ingenieure," by O. J. Marstrand, M. Am. Soc. C. E.

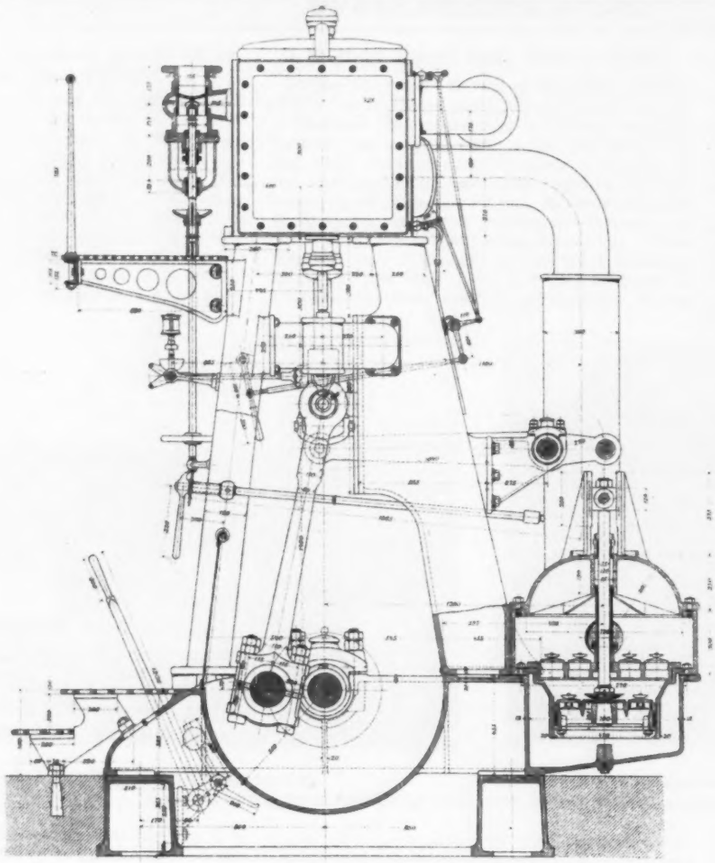


FIG. 4. TRANSVERSE SECTION OF ENGINE.

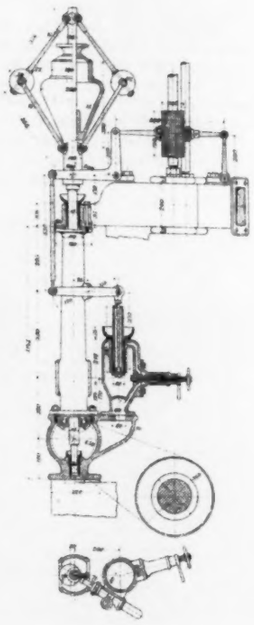


FIG. 5.
SECTIONAL ELEVATION
OF GOVERNOR.

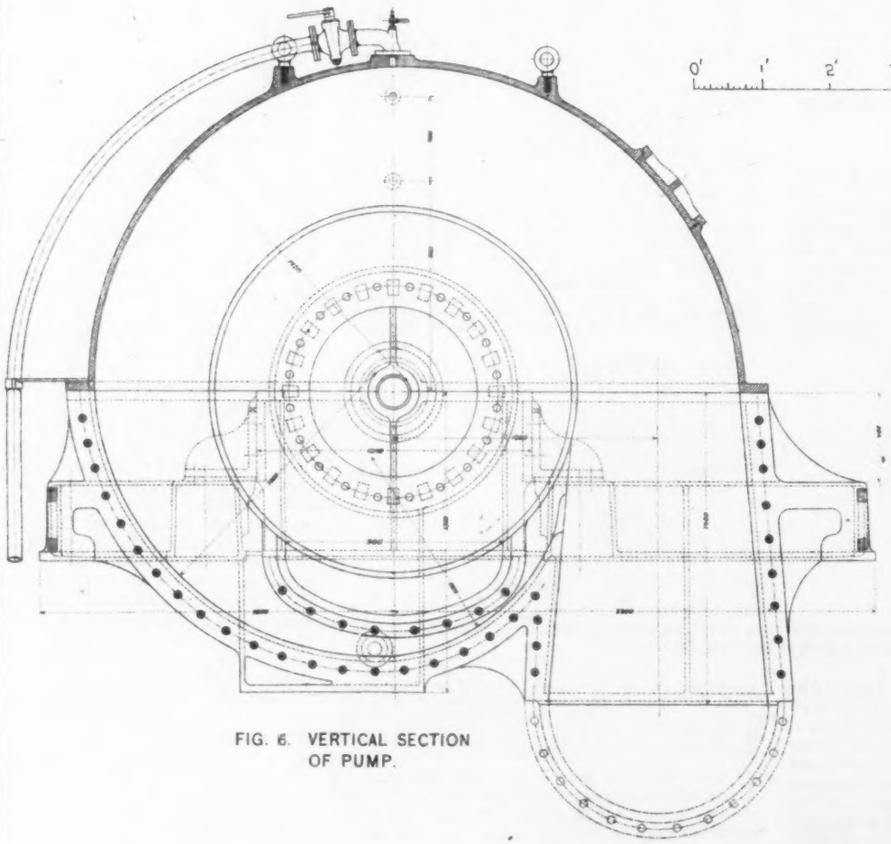


FIG. 6. VERTICAL SECTION
OF PUMP.

FIG. 2. HORIZONTAL

CENTRIFUGAL PUMP AND DIRECT CONNECTED ENGINE.

Otto H. Mueller, Jr., Designer of Engines. Michael von Kajlinger, Designer

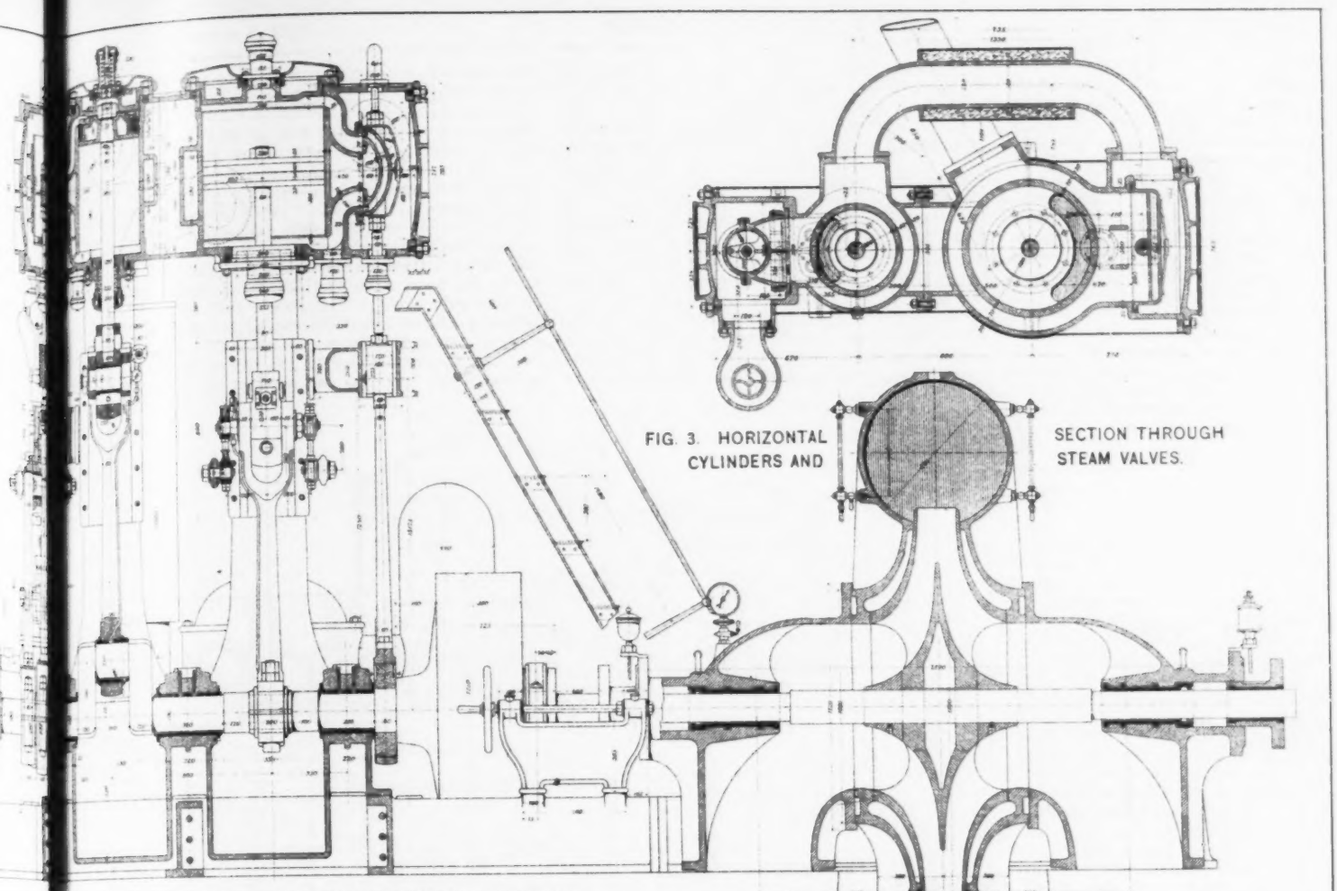
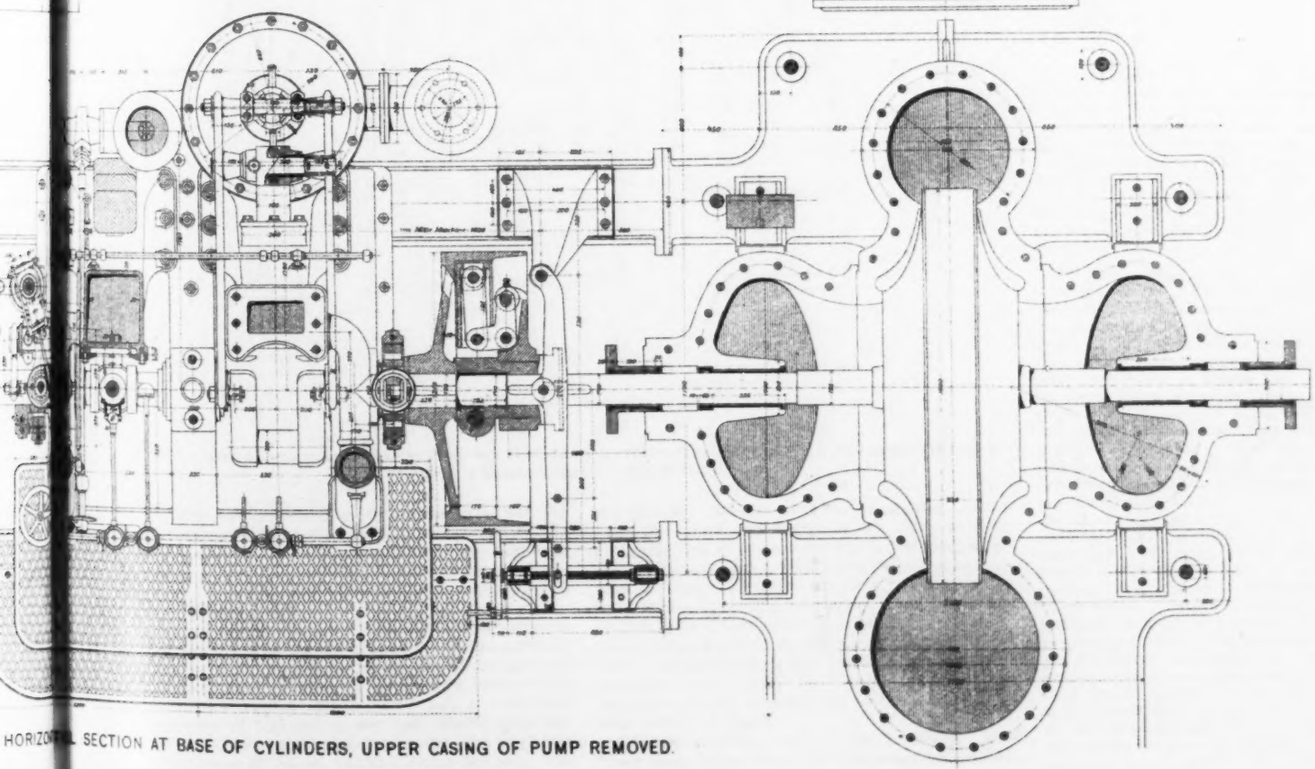


FIG. 3. HORIZONTAL SECTION THROUGH CYLINDERS AND STEAM VALVES.

FIG. 1. VERTICAL LONGITUDINAL SECTION.



HORIZONTAL SECTION AT BASE OF CYLINDERS, UPPER CASING OF PUMP REMOVED.

NGINE FOR THE SEWERAGE SYSTEM OF BUDAPEST, HUNGARY.

er, Designer of Pumps. Maschinenfabrik Stefan Roeck, Budapest, Contractors.

CHAS. HART & SONS, LITH., 26 VESEY ST., N. Y.

quent in Budapest, it was further specified that an estimated quantity of 27 cu. m. (7,132.8 gals.) per sec. should be lifted to, and discharged at, a height of 1.55 m. (5.1 ft.), corresponding to the water mark in the river at the periods of such storms.

Among the plans submitted, those of the Stefan Rock Works, Mich. v. Kajlinger, Engineer, were partially adopted. The plant, as shown in Figs. 7 and 8, consists of six vertical centrifugal pumps, discharging into the river, and five horizontal piston pumps, forcing the sewage to the fields for irrigation. Five large boilers of the double drum or double deck type provide steam for the pumping engines. The piston pumps and steam engines were designed by the author, Mr. Otto H. Mueller, Jr. Owing, however, to the cost, the irrigation iron brakes are moved out or in by means of a bell-crank lever, the centrifugal force tending to resist the former motion, being partially counteracted by weights. These couplings have stood well during the four years which the plant has been in operation.

The four steam engines are shown in Figs. 1 to 4 on the double-page plate. Their speed ranges from about 80 to 160 revolutions per minute, according to the varying conditions of flow and head. The operating steam pressure is 8 atmospheres, or 120 lbs. The engines are placed low for the purpose of reducing the suction height; and the air pump, which is set in the foundation frame, is located as near as possible to the engine, and has a short stroke 130 mm. (5.1 ins.), but a large diameter of cylinder. All operating levers and valves

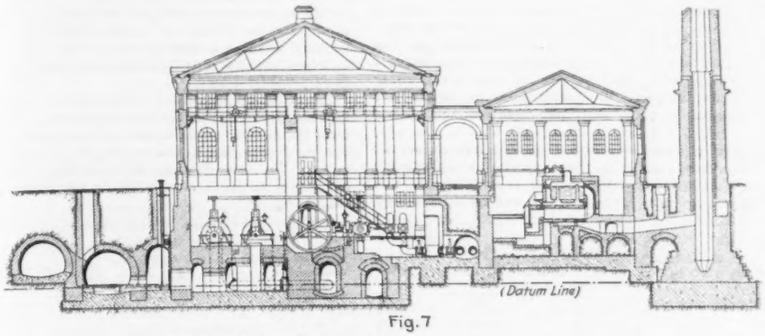


Fig. 7

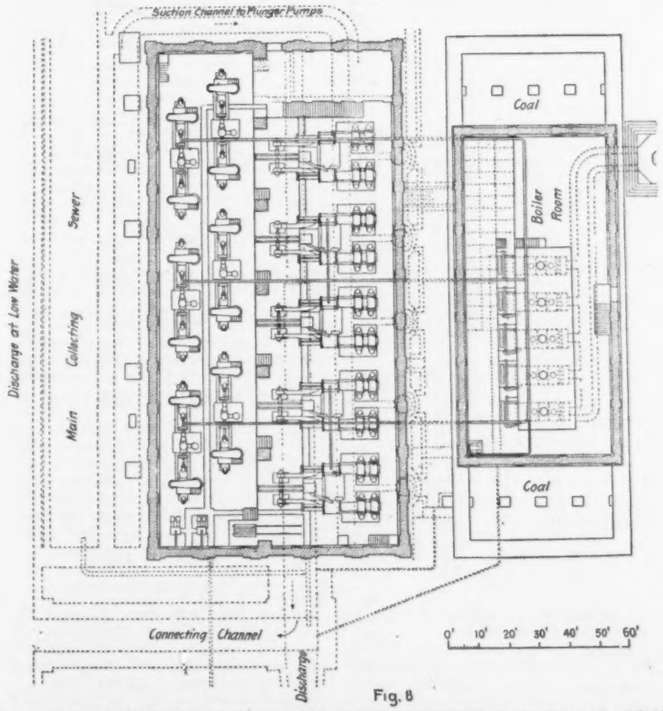


Fig. 8

FIGS. 7 AND 8.—PLAN AND TRANSVERSE SECTION OF SEWAGE PUMPING STATION AT BUDAPEST, HUNGARY, SHOWING ARRANGEMENT OF MACHINERY.

scheme was temporarily abandoned and only the centrifugal pumps were built. Two of the double boilers were also replaced by water-tube boilers in order to get up steam more quickly when necessary. To what extent this has been accomplished will appear later.

Each engine operates two centrifugal pumps, one of which is rigidly connected to the flywheel shaft, while the other can be moved in and out of gear when running by means of a Mechwart's friction coupling. Each pump has a maximum capacity of 2.25 cu. m. per sec. (35,664 gals. per minute), the total capacity of the six machines thus being 27 cu. m. (7,132.8 gals.) per sec. The details of these pumps are plainly shown in Figs. 1, 2 and 6 of the double-page plate. Fig. 9 herewith shows the Mechwart's coupling. Two cast-

are brought together over the operating stand, near the crank. In front of the two cast-iron uprights, the arrangement for oiling the crossheads and cranks is shown. The motion of the extensible oiling tubes is transmitted to the indicator cylinder by means of a short lever. This has proved to be a very convenient method. The indicator string is simply drawn through a hole in the lever, and passes back and forth therein when the indicator is not used. If a card is wanted, the engineer simply presses the string against the lever with the finger.

The low-pressure cylinder is provided with Trick slide valves, and the high-pressure cylinder has a Rider cut-off, the expansion valve moving inside the main valve. The expansion valves are operated from the shaft through eccentrics directly connected to the rods, while the main valves are operated by means of a rocker placed in the guide frame, the latter being substantially braced, as shown. The rocker is made of cast steel, and the levers are as short as possible to reduce the bending moments. Steam jackets were considered an unnecessary complication in such small engines, which would rarely be driven to their full capacity, and they have, therefore, been omitted. The governor used is a comparatively small Porter governor, which operates the expansion valve rod through a rack with teeth placed in a ring and engaging very broad teeth on the rod. A new contrivance for showing the number of revolutions is illustrated in Fig. 5 of the inset sheet. The governor is connected to a plunger which is forced upward by a constant, though adjustable hydraulic pressure obtained from a small pump operated from the governor stem through an eccentric or a pawl, forcing oil from a small reservoir into the pressure space under the plunger. The oil flows from and to the pump through a valve held by a spring which can be adjusted from the outside while the engine is running. The pressure can thus be regulated, and likewise the pull on the governor. The whole mechanism was placed within the space occupied by the engine, so as not to detract from its general appearance.

The official tests made previous to the acceptance of the plant gave the following results:

(1) To discharge 1.71 cu. m. (451.7 gals.) per sec. at a height of 4.75 m. (15.6 ft.), 1,498 kilos. (3,302 lbs.) of steam were consumed; (2) 3,873 cu. ins. (1,023.2 gals.) per sec. at 4.9 m. (16.1 ft.), 3,933 kilos. (8670.7 lbs.); (3) 1.574 cu. m. (415.8 gals.) per sec., at 2.6 m. (8.5 ft.), 1,071 kilos. (2,361.1 lbs.); (4) A maximum capacity of each of the six pumps equal to from 4.453 cu. m. (1,176.4 gals.) per sec., to 5.111 cu. m. (1,350.2 gals.) per sec., or 28.6 cu. m. (7,555.5 gals.) per sec. for all pumps at a height of 2.15 m. (7.1 ft.); (5) The Steinmueller water-tube boilers showed 69.3%, and the double deck boilers 82.54% efficiency. The coal used on an average of three tests yielded from 4,663 to 5,055 metric heat units, with 19% and 14% ashes, respectively. Finally the boilers were tested as to their capacity for quick steaming, with the result that it took a double boiler 76 mins., and a water-tube boiler 60 mins. to raise steam to a pressure of 120 lbs. from water at 15° C.

AN OFFICIAL TEST OF THE BOOK CONVEYING SYSTEM installed between the Capitol and the new Congressional Library, in Washington, D. C., was made Oct. 27. The test consisted in sending orders from the Capitol, a distance of about 1,000 ft., to the Library for certain books located in different parts of the book stacks and the return of the books. With small books this time was only ten minutes. With a volume of London Times of 1815, which could not be sent on the shelf carrier and required a special messenger, 13 minutes were consumed.

THE OMNIMETER, a new form of calculating instrument or slide rule, has been placed on the market by Theodore Alteneder & Sons, 945 Ridge Ave., Philadelphia, Pa. Briefly described the instrument consists of two concentric circular disks and a radial pointer. Upon the disks are a number of concentric circles divided into parts proportional to the logarithmic value of the functions they represent. Each series of circles corresponding to a single series of functions is marked distinctly by name and color. The principle upon which the instrument operates is exactly the same as that upon which the slide rule works, viz., that the sum of the logarithms of any two numbers is equal to the logarithm of their product and the difference of the logarithms of any two numbers is the logarithm of the quotient of those numbers. The instrument is made in three forms, which differ from each other only in the number of functions represented, in the quality of the material, and in the mechanical aids to calculation. The prices of the three forms are, respectively, $1, $2 and $3. The $3 instrument, one of which we have examined, is 7 ins. in diameter, and has non-absorbent bristol board disks and a transparent hair line pointer. The functions represented are logarithms, numbers, squares, square roots, cubes, cube roots, fifth powers, fifth roots, sines, tangents, versed sines and secants. The $1 instrument has all these functions, except fifth powers and fifth roots and secants. Such tests as we have made of the device have conveyed a favorable impression of its convenience and accuracy. It is always to be borne in mind, however, that no small scale slide rule can be depended upon to give more than three places of figures accurately in ordinary hands.

A DIAGRAM FOR DETERMINING THE SIZE OF BEAMS OF RECTANGULAR CROSS SECTION.

By John H. Gregory.*

The computation of wooden beams, although an easy process, may be considerably simplified by the use of the following diagram. Having computed the maximum bending moment on the beam, the moment of the resisting area is obtained by dividing this bending moment by the allowable outside fibre stress, and, knowing this, the size of the beam may be taken directly from the diagram.

According to the ordinary theory of beams, the bending moment which a beam of rectangular section will carry with a given outside fibre stress f, is

$$\frac{1}{6} f b h^2$$

in which b is the width, and h the depth of the beam. The moment of the resisting area is, then,

$$\frac{1}{6} b h^2.$$

An inspection of this equation shows that if h remains constant, the moment of the resisting area varies directly as the width b; hence the curve showing the relation between the moment of resisting area and the width b, for a constant height h, is a straight line passing through the origin.

The data for plotting the diagram are obtained as follows: Assume any width, as 16 ins., then compute the moments of resisting area with 16 as constant width and depths varying from 3 to 16

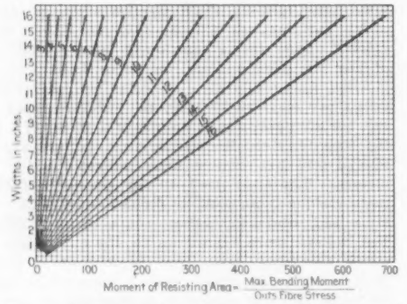


Diagram for Determining the Size of Wooden Beams of Rectangular Cross-Section.

ins. Thus for a depth of 9 ins. the moment of resisting area is 216. These moments are then plotted as abscissae, the constant width as an ordinate, and the points thus obtained connected with the origin by straight lines, each line being marked with the height which determined it.

A simple example will illustrate the use of the diagram. A wooden beam, 15-ft. span, with a total uniform load of 470 lbs. per running foot, has a maximum bending moment of 158,600 inch pounds. Dividing this by 1,200, the assumed allowable outside fibre stress, we have 132. Now, looking on the diagram for a moment of 132, we find the size of the beam to be 8 × 10-in., 6 × 12-in., or 4 × 14-in.

Conversely, the diagram may be used in determining the outside fibre stress, when the maximum bending moment and cross section of the beam is known. Take, for example, a 6 × 8-in. beam with a bending moment of 72,000 inch pounds. By the diagram the 6 × 8-in. beam has a moment of resisting area of 63.

$$\frac{72000}{63} = 1140$$

which is the outside fibre stress required.

The diagram includes all standard sizes, as beams larger than the 16 × 16-in. rarely occur. However, if desired, it can readily be enlarged to include any dimensions.

(A diagram for proportioning wooden beams and posts was given in our issue of Sept. 27, 1894, as devised upon a different basis of computation by Mr. Carl S. Fogh, of Denver, Colo. On April 28, 1892, we also published the diagram issued by Carnegie, Phipps & Co., for determining the sizes and weights of steel and iron floor beams.—Ed.)

* 57 Lumber District, Albany, N. Y.

EXPERIENCE WITH HOADLEY-KNIGHT AIR-MOTOR CARS IN WASHINGTON, D. C.

In our issue of Oct. 7 we printed reports presented to the Commissioners of the District of Columbia on the proposed use of compressed air traction on the Eckington & Soldiers' Home Ry. We are now able to present to our readers later reports, giving particulars of further tests of the Hoadley-Knight motor cars, with which this road has been experimenting. The reports are as follows:

Report of W. A. McFarland.

To the Engineer Commissioner of the District of Columbia.

Sir: I have the honor to submit the following report of tests of the Hoadley-Knight air motor car, made on Sept. 21, as directed by you. These tests, intended to demonstrate the ability of the air motor car to bring in a "cripple," were to consist of a service run from the power house, at 4th and T Streets northeast to 7th and B Streets northwest, from which latter point an electric motor car was to be hauled back to the power station, the usual number of stops being made, this to be followed by a run under similar conditions, the Brookland terminus of the line being used as the point from which to haul the electric motor.

Owing to a misunderstanding, the electric motor car had not been carried to 7th and B Streets previous to the test run, as was intended, and in consequence it was necessary to tow this car on the test run from the corner of Eckington Place and Florida Ave. to 7th and B Sts., N. W.. and return to 4th and T Sts., N. E.

Following are details of run: 1st. Air motor car No. 400. —Left 4th and T Streets northeast at 2:27 p. m.; gage pressure on reservoirs, 2,600 lbs.; 12 passengers carried. Reached Eckington Place and Florida Ave. at 2:32, with pressure of 2,350 lbs. At this point electric motor car No. 5, of Eckington and S. H. Ry. Co. was taken in tow; weight of trailer stated as 15,000 lbs. Left Eckington Place and Florida Ave. at 2:36; reached 7th and B Sts., N. W., at 2:48½, with pressure of 1,750 lbs., six stops having been made en route. Left 7th and B Sts. at 2:55 p. m., carrying 20 passengers, reaching 4th and T Sts. at 3:17, with pressure of 500 lbs. Stops made on return trip, 14.

Summary: Distance, 5 miles; time, exclusive of terminal stops, 50 minutes; speed, including intermediate stops, 6 miles per hour; total fall in pressure, 2,100 lbs.; capacity of reservoir, 52 cu. ft.; total volume free air used, 7,413 cu. ft.; cu. ft. free air per mile, 1,482; weight motor car stated as 20,000 lbs.; weight of trailer stated as 15,000 lbs.

2d. Left 4th and T Sts., N. E., at 3:24 p. m., with pressure of 1,800 lbs.; 10 passengers carried; electric motor car No. 5 in tow; reached Brookland at 3:35; pressure, 1,050. Left Brookland 3:37; pressure, 1,000 lbs.; reached 4th and T Sts., N. E., at 3:46, with pressure of 600 lbs. Total number of stops, 11.

On the third trip, Sept. 22, when the air motor car reached Florida Ave., an electric car, with 40 passengers on board, was held up by a breakage of the trolley wires and was unable to proceed. The car was taken in tow and hauled to the corner of 4th and T Sts.

The third trip, on Sept. 23, was made during a violent rain storm. The tracks at Eckington Place and Florida Ave. were covered with water fully a foot deep when the car reached that point going west. The only delay occasioned was by a horse car which had been derailed by the heavy wash.

During the test the car ran with great regularity, being always ready at the appointed time; the only impediment to rapid motion being the slow-moving horse cars running on the same track. The car starts and stops without shock or violence, responding promptly to the work and speed demanded, and runs with little noise or lateral vibration. The present appliances for compressing and supplying air are crude and imperfect, but with a proper and economically arranged plant there is no reason to doubt the successful operation of the system.

Respectfully submitted, Geo. H. Bailey.

Washington, D. C., Sept. 22, 1897.

Summary: Distance, 2.8 miles; time, exclusive of terminal stops, 20 minutes; speed, including intermediate stops, 6 miles per hour; total fall in pressure, 1,250 lbs.; capacity of reservoirs, 52 cu. ft.; total volume free air used, 4,236 cu. ft.; cu. ft. free air per mile, 1,512; weight of motor stated as 20,000 lbs; weight of trailer stated as 15,000 lbs.

The reservoir capacity of the motor car, 52 cu. ft., is the same as when the last official tests of this car were made; the air is contained in 12 long bottles stored under the seats, and 2 long and 10 short bottles hung under the car body.

No difficulty was experienced in making the above runs.

Very respectfully, W. A. McFarland.

Washington, Sept. 22, 1897.

Report of Geo. H. Bailey.

Capt. W. M. Black, U. S. A., Engineer Commissioner, District of Columbia.

Sir: In accordance with your instructions to make a test of the Hoadley-Knight air motor, running on the tracks of the Eckington & Soldiers' Home Ry., I have the honor to report that the duty has been performed and the result is respectfully submitted.

According to agreement with Mr. Schoepf, the test was to be four trips per day for four consecutive days, running from the Eckington car house, near the corner of 4th and T Sts., to 15th and G Sts. and return, a distance of 5.44 miles. The test commenced Wednesday, Sept. 22, and the points observed are shown by the following tabular statement:

Date.	Number of trip.	Time.	Pressure, lbs.	Time consumed.	Loss of pressure, lbs.	Cu. ft. free air, per mile.	Passengers.	Stops.
Sept. 22.	1	Starting ..... 8:00 a.m.	2,400	49 mins.	1,775	1,152	25	13
		15th and G Sts.. 8:24 "	1,450					
		Car house ..... 8:49 "	625					
Sept. 22.	2	Starting .....12:00 m.	2,200	45 "	1,650	1,073	10	7
		15th and G Sts..12:22 p.m.	1,350					
		Car house .....12:45 "	600					
Sept. 22.	3	Starting ..... 4:00 "	2,500	49 "	1,900	1,235	10; 40 from Fla. av.	9
		15th and G Sts.. 4:22½"	1,525					
		Car house ..... 4:49 "	600					
Sept. 22.	4	Starting ..... 8:00 "	2,250	47 "	1,600	1,040	6	4
		15th and G Sts.. 8:24 "	1,400				6	3
		Car house ..... 8:47 "	650					
Sept. 23.	1	Starting ..... 8:02 a.m.	2,500	49 "	1,725	1,122	40	11
		15th and G Sts.. 8:26½"	1,525				3	3
		Car house ..... 8:49 "	775					
Sept. 23.	2	Starting .....12:00 m.	2,450	50 "	1,675	1,090	6	6
		15th and G Sts..12:21 p.m.	1,550					
		Car house .....12:50 "	775					
Sept. 23.	3	Starting ..... 4:00 "	2,500	49½ "	1,950	1,263	16	12
		15th and G Sts.. 4:29 "	1,500				35	10
		Car house ..... 4:49½"	550					
Sept. 23.	4	Starting ..... 8:00 "	2,400	47 "	1,625	1,056	4	4
		15th and G Sts.. 8:24 "	1,500					
		Car house ..... 8:47 "	775					
Sept. 24.	1	Starting ..... 8:00 a.m.	2,500	43½ "	1,600	1,040	10	8
		15th and G Sts.. 8:21½"	1,625				4	6
		Car house ..... 8:43½"	900					
Sept. 24.	2	Starting .....12:00 m.	2,300	45 "	1,550	1,007	6	6
		15th and G Sts..12:22 p.m.	1,475				5	4
		Car house .....12:45 "	750					
Sept. 24.	3	Starting ..... 4:01 "	2,500	44½ "	1,600	1,040	5	6
		15th and G Sts.. 4:21 "	1,650				19	7
		Car house ..... 4:44½"	900					
Sept. 24.	4	Starting ..... 8:00 "	2,325	44 "	1,575	1,024	2	3
		15th and G Sts.. 8:20 "	1,525				3	4
		Car house ..... 8:44 "	750					
Sept. 25.	1	Starting ..... 8:00 a.m.	2,500	43½ "	1,650	1,074	10	14
		15th and G Sts.. 8:22 "	1,575				6	4
		Car house ..... 8:43½"	850					
Sept. 25.	2	Starting .....12:00 m.	2,275	46½ "	1,575	1,025	16	6
		15th and G Sts..12:21 p.m.	1,450				6	7
		Car house .....12:46½"	700					
Sept. 25.	3	Starting ..... 4:00 "	2,475	46 "	1,700	1,108	16	5
		15th and G Sts.. 4:21 "	1,600				16	5
		Car house ..... 4:46 "	775					
Sept. 25.	4	Starting ..... 8:00 "	2,235	47 "	1,585	1,034	11	4
		15th and G Sts.. 8:25 "	1,375				8	4
		Car house ..... 8:47 "	650					

missioners are required to pass judgment by Oct. 1, 1897, on the question whether compressed air motors, as experimented with or operated by the Eckington & Soldiers' Home and Belt Ry. companies, have proven "to be in all respects a proper and satisfactory motive power for the speedy and convenient propulsion of street cars."

The preliminary report submitted by me July 17, 1897, covered the first tests made. At a hearing given July 30, 1897, the receiver of the companies in question submitted a statement.

This was carefully examined, and it was found that the figures as to running expenses, contained in the report of July 17, 1897, were questioned by Mr. Schoepf, who submitted certain data to show a very low cost of operating the air motor. It was found impossible to verify these data from any information available, owing to the fact that there is no air motor line in operation running with machinery or under conditions at all similar to those found here.

It was impossible, from the receiver's paper itself, to verify the figures given. The figures submitted by him rest simply on assertions.

In accordance with your instructions Assistant Engineer McFarland was sent to New York during the month of August to inspect the working of the air motor car then running there on Lenox Ave. Mr. McFarland's report is appended.* It will be noted that he reports that the car was running successfully as far as the mechanical operations are concerned, but that he was unable to obtain data regarding the actual operating expenses.

On Sept. 21, at the request of the Commissioners, further tests were made as to the ability of the air motor car to tow a disabled car from the farthest point on the line at which a breakdown would be likely to occur back to the power house. The test was successful, as shown in Mr. McFarland's report, dated Sept. 22, 1897.

On Sept. 22, 23, 24 and 25 a further test was made by having the car make schedule runs on a definite route. Owing to the insufficiency of the compressor plant the receiver stated that he was not able to make more than four trips daily. This test was also mechanically successful, as shown by the report of Mr. Geo. H. Bailey, Engineer of Bridges, who represented the District and who was present on each trip.

From all of the above it is evident to me that it is mechanically possible to operate an air motor car, of the pattern and capacity of the one tested, over the routes of the Eckington & Soldiers' Home & Belt Rys. The only improvement needed for the comfort and convenience of the passengers are that the exhaust should be muffled and that the air from the exhaust should be discharged at a point from which it can escape without blowing up the excessive amount of dust now noted when ascending grades or starting under a heavy load.

The economic questions presented remain unsettled, and I do not see how they can be settled conclusively excepting by actual operation of the line or a portion of it with air motor cars under service conditions. It will be remembered that it has been claimed by the advocates of the air motor system that the car can be run with an expenditure of 400 cu. ft. of free air per mile, and that the reservoir capacity is sufficient to permit a run of ten miles without recharging.

In my report of July 17, 1897, attention was invited to the practically untried nature of the experiment of using compressed air at exceedingly high pressure as a motive power. The reports of the tests all tend to show that the problem thus presented has not been solved entirely satisfactorily; that the machinery in use cannot be operated under this high pressure, with a normal load, without very great loss of power. To show this, attention is invited to the following figures: In the tests of Sept. 21 the two trips made—each practically half way down grade and half way up grade, respectively—showed an average air consumption per mile of 1,134 cu. ft. down grade, and 1,827 cu. ft. per mile up grade. On this occasion, it will be remembered, the air car pushed or towed a trailer car weighing 15,000 lbs., and the work devolving upon the motor was very great, quite beyond the normal amount, and required a large consumption of air. Here the least consumption is found to be on the down grade trips, as it should be.

In the schedule trips the air motor had to move its own weight and a load of passengers only (the normal load). The line run was from the power house, at 4th and T St., northeast, to 15th and G St., northwest, the latter point being 40 ft. lower in elevation than the former. In other words, the trip from the power house was made on a down grade, with the exception of a hill on New York Ave., and on the return trip the car had to be lifted through the elevation above mentioned. In the 16 trips made the average consumption of free air per mile on the down grade was 1,157 cu. ft. and on the up grade 1,001 cu. ft. The amount of free air used on the down grade was 156 cu. ft. more than that used on the up grade. It is noted further that a car started from the power house with an average pressure of 2,397 lbs. and started on its return trip with an average pressure of 1,504 lbs., having at the end of the run at the power house a remaining pressure of 726 lbs., all of which shows conclusively loss of power while working under heavy pressures with a normal load.

This fact apparently seems to be well understood by the persons interested in the introduction of the air motor, and we find that during the past summer, for the first time, so far as is known, claims have been made that it will be necessary, and had always been contemplated under the law, that a pipe line for recharging stations should be laid. At first this pipe line was asked for simply as a feeder for terminal stations. In Mr. Schoepf's letter of Sept. 20, appended (enclosure 5), it will be noted that the receiver there states that recharging stations will be made at intervals of one-half mile.

In other words, it would seem to be admitted that practical operation over long routes with heavy grades would require such great storage capacity for the compressed air, and consequently such great pressures and consequent loss of power, that the air motor promoters themselves now desire relief in the shape of recharging stations at intervals short enough to permit running the cars with a less pressure in the reservoirs. This, it is submitted, presents the air motor as a means of street car propulsion in a light very different from that claimed when the enabling laws were discussed and passed. Besides, the proposition would seem to be without warrant of law.

Returning to the proposition of using air motor cars with terminal recharging stations only, as previously stated, the cost of operating the air motor cars under the unfavorable mechanical conditions this would prescribe cannot be determined. The tests have shown that air motor cars, having the power and reservoir capacity of those tested, are able to meet the mechanical requirements of the Eckington and Belt systems, so far as it is possible to show this by tests made during short periods and entirely in the summer season.

In answer to the question as to whether compressed air motors have proven to be in all respects a proper and satisfactory motive power for the speedy and convenient propulsion of street cars, it must be said that, mechanically, air motor cars of the type, power and reservoir capacity of that last tested, with a few slight modifications, have proved satisfactory, in so far as the passenger requirements are concerned, but that the capability to compete economically with the best type of underground electric street car equipment has not been proved and is doubtful.

Under the circumstances, it is my opinion that the Commissioners cannot refuse to approve of an equipment of these lines with air motor cars of the type, power and reservoir capacity of those tested, and provided with arrangements for muffling the air and discharging it at some point where it will have no effect upon the roadway, and also to authorize the construction of a sufficient limited number of conveniently located terminal charging stations, provided with proper recharging machinery.

Very respectfully yours, W. M. Black,
Captain, Corps of Engineers, U. S. A., Engineer Commissioner, District Columbia.

Washington, D. C., Sept. 20, 1897.

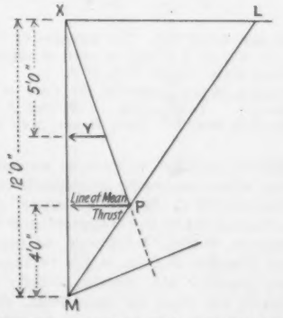
* Engineering News, Oct. 7, 1897, p. 231.

THE COMPUTATION OF STRAINS IN COAL AND GRAIN BINS.

The discussion of this subject in our issue of Sept. 23 has brought us a number of letters in which many diverging views are presented upon the subject. We print these letters below, appending in some cases such comment as seems to us needed. It will be noticed that in several cases questions asked by one correspondent are well answered by another. The letters are as follows:

Sir: I have read your article on the "Computation of Strains in Coal and Grain Bins" with much interest, and would be pleased to know if the assumption in my sketch would be correct.

The line of mean thrust being taken as acting at ⅓ the height of the vertical wall, is it correct graphically to join points X P and M P and assume that a line Y at say 5 ft. down would represent the thrust exerted at that point by the mass X L M.

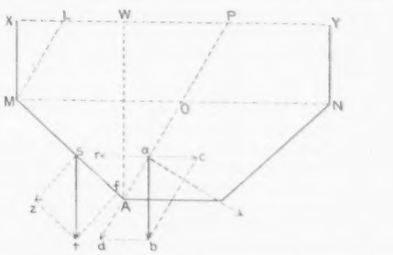


My reason for asking this question is that the main bents are placed from 10 to 12 ft. apart and horizontal stringers are run from bent to bent to carry the wall sheeting. In order that there be no bulging between the bents it is necessary to determine the thrust exerted at each vertical foot of height to arrive at the required section of said horizontal stringers. Thanking you in advance for your answer, Yours truly, F. B. F.

P. O. Box 161, West Orange, N. J. Sept. 25, 1897.

(This method is correct, provided the value of the mean thrust is calculated as described for vertical walls. It is of course true, however, that P would not fall upon the line L M unless it did so by accident.—Ed.)

Sirs: Referring to your discussions of strains in a coal bin in your issue of Sept. 23, I am much interested in your treatment of the problem. But as it requires a stretch in the imagination to assume coal acting as a fluid, I would venture to make the following suggestions. Making use of your Fig. 2, consider a longitudinal partition constructed on the line A W, then the portion A W X M would act as a solid as far as the tie M N on the right of A W is concerned. The portion A W P would then be treated as a wedge according to Weyrauch's Theory of Retaining Walls. The sum of the strains produced by these two portions would be the maximum strain in the tie M N.



Yours truly, W. H. Sadler,

Scranton, Pa., Sept. 27, 1897.

(The letter of Mr. Noyes below seems to explain the action of granular masses so that it should not require much "stretch of the imagination" to understand it. The method for computing the strains is correct and is explained in detail in Professor Church's letter, given herewith.—Ed.)

Sir: I have not attempted to go through the calculations of strength on the coal-bin question, but this idea strikes me at the outset: The jar to which any elevated bin is subjected by machinery under it reduces the angle of repose of the material, and this action is continuous; so that the stresses in the mass of material are constantly approximating the stresses (or pressures) that would exist in a fluid mass of the same specific gravity as the average of the mass of coal or other substance stored.

Therefore, it is not safe to figure on any stresses less than would be caused by a fluid mass; and it is conceivable that under some circumstances any pressure due to unsymmetrical form of a structure might be greater even than in a fluid mass; because the material having had an extra jar in one direction cannot recoil as a fluid would after the jar; but would rather act as a continuously driven wedge. Yours truly, Joseph B. Noyes.

Binghamton, N. Y., Sept. 24, 1897.

(Our correspondent's letter presents points worth consideration. We may point out, however, that such a wedging action as he thinks possible would be less likely to take place in a smooth granular material such as coal or grain than it would in a material like broken stone of large size or hard iron ore.—Ed.)

Sir: In your issue of Sept. 23 I notice a discussion on the design of the coal bin at the Paterson Electric Light station. Permit me to point out that one factor, which, to my mind, is quite important, has been entirely omitted both from the computation of Milliken Bros. and also by you in your commenting upon the same. This is the bending moment in the tie A B, resulting from the load of coal resting upon the same. In addition to this, you will notice from the detail furnished by Milliken Bros. showing the connection of the tie to the gusset plate that the angles forming these pieces are turned with the horizontal flange to the top, thus decreasing its ability to withstand the additional strain resulting from the bending moment. Not only so, but if the detail referred to is drawn correctly to scale it would appear that in computing the net section four rivet holes and not two should have been deducted. I believe that each of these three considerations has an important bearing upon this case.

Referring to your article in the same issue on the Computation of Strains in Coal and Grain Bins, it seems to me that the method illustrated is certainly correct, and I believe is a valuable contribution to this subject. Might I suggest that a similar article upon the strains produced

in a circular tank filled with wheat or coal would be even more valuable? As far as I know, there is little or nothing of a reliable nature published upon this question. The storage of wheat and coal in circular bins is a matter that is coming rapidly to the front, and I believe that it is important that the principles upon which the strains are produced under these circumstances should be thoroughly understood. Of course the strains produced in a circular tank filled with water are very well known, but the same is by no means true in the case of a circular tank loaded with either wheat or coal. Yours truly,

Frank J. Llewllyn.

Minneapolis, Minn., Sept. 28, 1897.

(How much bending stress the settling coal in the bin would bring upon the horizontal members buried in it is something which defies computation, and is a matter for good judgment to determine. We believe, however, that this tension member with its upper horizontal surface 6 ins. wide must have had a considerable transverse stress upon it due to the downward movement of the coal, for in nearly all coal or grain bins the contents are drawn out through bottom chutes. It is fair to say, however, that in the Paterson bins, the chutes were located midway between the transverse trusses which supported the sides of the bin.

It is worth considering in this connection, whether good design would not call for the use of round rods or eye-bars for tension members which are to be buried in a settling mass of coal. Certainly the transverse strain in these could be neglected with more reason.

As for the stresses in circular bins, we believe that the best method of computing them is to consider the material contained as a liquid, and that this method will give stresses which will not differ considerably from the actual stresses. If our correspondent has reasons to the contrary, we shall be pleased to hear them.—Ed.)

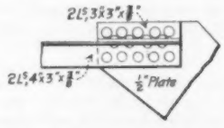
Sir: Referring to the article in your issue of Sept. 23, entitled "The Design of the Coal Bin at the Paterson Electric Light Station." At the close of the second communication from Milliken Bros. is given a sketch showing the connections of the tie "A B." This sketch is not drawn to scale, I presume, but the dimensions given are sufficient to indicate that the rivets in the opposite legs of the tie are not more than 1½ in. apart. Two rivets, in opposite legs of an angle, but only 1½ in. apart, practically result in reducing the net section of the angle by two holes, so that in reality the net section of the tie "A B" should be obtained by deducting four holes, instead of two, as indicated in the first communication of Milliken Bros. Following up the figures that they give, we obtain 3.5 sq. ins. as the net section of "A B," and a consequent strain per sq. in. of 21,200 lbs.

It is possible that in detailing the connection, the distance between the first rivet in the horizontal and the first in the vertical leg was taken so that the section of one angle was not weakened by two holes, but from the sketch as published this does not appear to be the case.

In fact, from the length given for the lug, and the allowable minimum spacing of rivets, I doubt if it is possible to so detail the connection, with that number of rivets, that the section of each angle is not reduced by two holes. Yours, truly, Alfred M. Mosscrop.

Rochester, N. Y., Sept. 30, 1897.

(We reprint the sketch of the connection referred to from our issue of Sept. 23. Our correspondent's point appears to be well taken. That is to say,



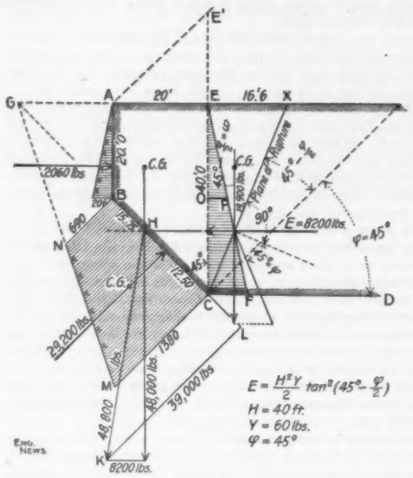
the rivets in the horizontal and the vertical legs of the angle appear to have been staggered only 1½ ins., and if this is the case good practice would call for the reduction of more than the metal of one rivet hole to obtain the net section.—Ed.)

Sir: It appears to me that under certain assumptions the determination of the pressure upon the sides of a coal or grain bin is comparatively a simple matter. Given the weight of the coal or grain per unit of volume and its angle of repose, the pressures within the mass or upon the sides retaining the same can be taken to follow the laws usually assumed for a granular mass without cohesion.

The above data given and the assumption accepted, the process of obtaining the pressures is as follows:

(A) Surface of coal or grain level.

Let A B C D represent one side and the bottom of the bin and assume the coal or grain level with the top of the side A B.



First determine the pressure upon the vertical plane E C due to the mass upon the right; this is given by the formula

$$E = \frac{H^2 Y}{2} \tan^2 \left(45° - \frac{\psi}{2} \right) *$$

where

E = required thrust or pressure

H = vertical height of plane C E

Y = weight of a unit volume of coal or grain

ψ = angle of repose of coal or grain.

The force E acts parallel to the surface of the coal or grain and hence, normal to E C.

Since in a granular mass without cohesion the intensity of the pressure upon any plane varies directly with the depth below the surface, the total pressure E may be represented by the triangle E C F, the intensity of the pressure or E being represented by C F. The application of the resultant thrust E is evidently at a point above C a distance equal to ⅓ E C. Having determined the thrust E and its location we need not consider the coal or grain on the right of C E further, but replace its effect by the thrust E.

To determine the thrust upon the side B C we first consider the plane G C, or B C produced until it cuts the surface line of the coal or grain produced. The pressure upon the plane G C equals the resultant of the force E found above and the weight of the triangle of coal or grain G E C. The weight of this mass is easily computed. Letting this weight act through the center of gravity of the triangle G E C, by parallelogram of forces we obtain the resultant H K in magnitude and direction.

The normal and tangential components of H K are K L and H L. Now since the intensity of pressure varies directly as the depth, the normal component can be represented by the triangle G M C having an area equal to the magnitude of K L. The total normal pressure upon the plane B C is then equal to the area of the trapezoid N B C M and is applied at a point between B and C found by drawing a line through the center of gravity of the trapezoid N B C M parallel to M C. The pressure upon the vertical side A B is evidently equal to the area of the triangle E O P and is applied at a distance above B equal to ⅓ A B.

With the exception of the computation of E (and E can be found graphically) the above process is practically graphical and also very simple.

(B) Surface of coal or grain heaped—slope being at angle of repose.

In this case it is practically impossible to obtain the actual thrust against the vertical C E E' unless the surface A E' is assumed to be continuous—then the thrust is given by the formula

$$E = \frac{H^2 Y}{2} \text{ Cos } \psi$$

H in this case being E'C. The direction of E will be parallel to the surface A E' and its point of application at a point distant above C equal to ⅓ E' C.

The remainder of the process is the same as outlined for level surface. Yours truly, Malverd A. Howe.

Rose Polytechnic Institute, Terre Haute, Ind., Sept. 28, 1897.

(Prof. Howe's method appears to us correct up to the point where he begins to compute the pressure on the side B C. It will be noticed that he takes the weight not of the trapezoid A B C E but of the triangle G E C. Doubtless, he intends to deduct the triangle G B A in his further calculation; but whether his method actually effects this or not is not clear to us. Prof. Church's method, given below, will be seen to be quite similar to Prof. Howe's, and seems to us to have an advantage in simplicity.

In a personal letter Prof. Howe questions the correctness of the method of computing pressures due to a heaped bin, which was given in our editorial of Sept. 23. We have explained our position on this point more fully in commenting below on the letter of Mr. Edwards.—Ed.)

*Howe's Retaining Walls for Earth. John Wiley & Sons, N. Y.

Sir: Your editorial comments on the computation of strains in coal and grain bins, as given in your issue of Sept. 23, have come to my notice. There are some points in regard to your method of computing the strains that I beg to ask you to kindly explain further. In regard to the

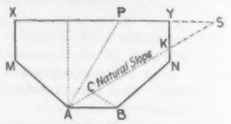


Fig. 1.

coal pocket sketched in your article, as shown in Fig. 1, are not your conclusions based on the assumption that the mass which determines the pressure on the side of the bin or structure, is the mass A M X S, not the mass A M X Y K, which actually does determine the pressure? Considering this point from perhaps a more exaggerated case, like that shown in Fig. 2, would you assume it

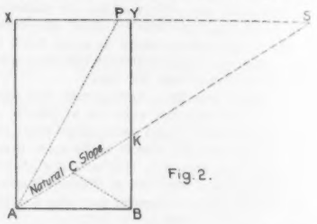


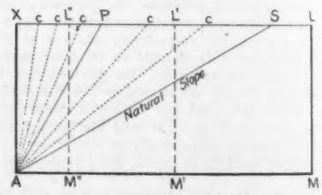
Fig. 2.

correct in getting the pressure on the side A X to take the weight of the triangle A X P when the line A P is drawn so as to bisect the angle X A S? These points are not brought up with any idea of getting into a controversy, but inasmuch as you have gone into this matter carefully, we thought you were in a position to give us further enlightenment on the above mentioned points. Thanking you in advance for the courtesy of giving the matter attention, we remain, Yours truly, J. H. Edwards

East Berlin, Conn., Oct. 1, 1897.

(The question our correspondent raises is very apt to puzzle designers, and we will endeavor to explain more clearly what seems to us the proper way of considering the matter.

To take the most general case, suppose we wish to determine the pressure against the vertical plane A X of a mass of granular material behind it. To make the side A X safe we must determine the greatest pressure that can possibly come against it. Let the line A S be the natural slope of the material. Evidently, then, the greatest amount of material that can exert pressure against A X will be that whose section is A X S. But we do not know that this whole mass will start to slide down



the plane A S, if the side A X were to yield slightly. Any other wedge, A X P for example, may start to slide down, and the pressure which such a wedge would exert against the material to the right of the line A P might hold that material in place. To get this idea more clearly in mind, suppose the material held in place by the side A X to be not coal or grain, but earth with clay seams radiating from the point A upward to the surface. The engineer then must consider the possibility that any of these wedges A X c may start to slide, and must find what one of them would exert the greatest pressure upon the side A X.

Now, as we explained in our former article, a mathematical solution of this problem shows that the wedge of maximum pressure is that whose inclined side bisects the angle between the vertical

and the line of natural slope. If any of our readers doubt the soundness of this theory, they can make a practical test of its correctness as follows. Build a small bin and hinge the side A X at A, supporting it by a prop. Fill the bin even full with grain or coal, and then let the side A X move slightly forward. It will be found that settlement will take place, and will be evident on the surface of the grain from X back to the point P, while there will be no settlement noticeable of the surface P S.

We are now ready to deal with the point our correspondent raises. If the side L M be moved to the position L' M', it will not affect at all the pressure on the side A X, for the wedge of the maximum pressure X A P acts the same as before. If, however, the side L M be moved to the position L" M", the pressure on the side A X will be reduced, the weight of the wedge being now only that due to the volume of the four-sided figure X L" A.

In other words, what we do in every case is to draw the slope of maximum pressure from the foot of the retaining wall, or bin side, and find the weight of the mass of material which actually rests on and tends to slide down this slope.—Ed.)

Sir: It seems to me that a very direct way of treating this problem is as follows (I have employed the same letters in the diagrams as in your Fig. 2 on p. 201, issue of Sept. 23):

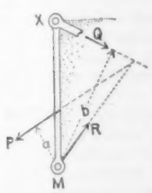


Fig. 4.

We first compute the tension Q in the upper oblique tie-rod (Fig. 4 accompanying this) by a consideration of the stiff vertical plate M X, hinged at M and acted on by the thrust P of the coal, the tension Q, and the reaction R at the hinge. P having been determined in amount and position by the theory of a vertical retaining wall, we have by moments about M,

$$Q\,b = P\,a. \qquad (1)$$

Let us now consider, in Fig. 5, the trapezoidal mass of coal M X W A (W A being a vertical plane through A), together with the two rigid plates X M and M A. The forces external to this compound mass are: The two tie-rod tensions, Q and Q'; the reaction, R', of the hinge at A; a thrust P' distributed over the vertical plane W A, exerted by the granular material situated on the right of that

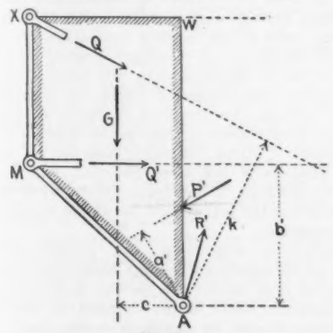


Fig. 5.

plane; and the weight G, of the trapezoid of coal X W A M, applied in a vertical through the center of gravity of that trapezoid. Regarding the plane W A as the right hand face of a vertical wall, we find the resultant thrust P' exerted upon it by the material on the right, by the same simple theory as P. Of the three supporting forces, Q, Q', and R', Q is already known, and R' has no moment about the hinge A. Hence, taking moments about that hinge for this body in Fig. 5, we have

$$Q\,k + Q'\,b' = G\,c + P'\,a'\,; \qquad (2)$$

from which Q' can be found.

By summing horizontal and vertical components in Fig. 5, we might also find R' in amount and position. With R' and Q' known, a consideration of the stiff plate A M, subjected, as it is, to the force Q' at M, to the resultant of Q and P at M (= R reversed), to the force R' at A, and to the resultant "earth" pressure distributed along M A, it becomes a simple matter to determine the amount and position of this "earth" pressure on M A.

It would be on the side of safety, of course, to consider P horizontal in getting the value of Q, for the design of the upper tie-rod; whereas, in determining Q', besides considering P' horizontal it might be advisable to use for Q a value based on the assumption that P is oblique (as in Fig. 4). (For simplicity, the weights of the plates X M and M A have been neglected in the above.)

Sincerely yours, I. P. Church.

Cornell University, Ithaca, N. Y., Sept. 25, 1897.

Sir: Allow me to make the following objections to the discussion of the strains in coal bins in your issue of Sept. 23:

The value of $\frac{90^\circ - \varphi}{2}$ for the angle of the slope of maximum pressure with the vertical is applicable in the case of horizontal pressures against vertical sides, but not in the case under consideration. It is further not allowable to suppose the slope of maximum pressure P A (Eng. News, Sept. 23, 1897, page 200) frictionless; and if supposed frictionless it can only give a normal reaction. A horizontal reaction a r is with this supposition impossible. As this method is entirely based upon the law of friction, it is also not allowable to consider the mass M X P A as a liquid for computing the center of pressure.

For a systematic solution of the problem, I think the method of the slope of maximum pressure should be avoided entirely; and I propose therefore the following *theory for normal pressures of a granular mass against inclined sides*, based upon the general principles given by Rankine, and from which he deducts his formula for the horizontal pressures against vertical sides.

It is perhaps not superfluous to observe that Rankine's formula for vertical sides and the method of the slope of maximum pressure give identical results.

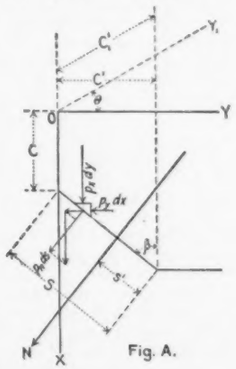


Fig. A.

In Fig. A

p_x = unit pressure on d_y,

p_y = unit pressure on d_x,

p_y = unit normal pressure on ds,

N = total normal pressure on inclined side S,

w = weight unit of mass,

φ = angle of friction.

When the upper surface of the granular mass O Y is horizontal, the general principles, referred to, will give:

$$p_x = wx; \quad \text{and } p_y = wx \times \frac{1 - \sin\varphi}{1 + \sin\varphi}$$

further is:

$$x = \frac{y}{\tan\beta} + C; \quad \text{and } dx = \frac{dy}{\tan\beta}$$

and

$$p_n ds = p_x dy \sin\beta + p_y dx \cos\beta;$$

consequently

$$p_n ds = w\left[\sin\beta + \frac{(1 - \sin\varphi)\cos\beta}{(1 + \sin\varphi)\tan\beta}\right]\left(\frac{y}{\tan\beta} + C\right)dy$$

$$p_n^2 ds = w \times \frac{1 + \sin\varphi\,(1 - 2\cos^2\beta)}{(1 + \sin\varphi)\sin\beta} \times \left(\frac{y}{\tan\beta} + C\right)dy$$

and

$$N = \int_{y=0}^{y=C'} p_n ds = \int_{y=0}^{y=C'} w \times \frac{1 + \sin\varphi\,(1 - 2\cos^2\beta)}{(1 + \sin\varphi)\sin\beta} \times \left(\frac{y}{\tan\beta} + C\right)dy$$

$$N = w \times \frac{1 + \sin\varphi\,(1 - 2\cos^2\beta)}{(1 + \sin\varphi)\sin\beta} \times \left(\frac{C'^2}{2\tan\beta} + CC'\right) \qquad (1)$$

The distribution of the normal pressure over the inclined side as represented in Fig. B by the trapezoid a b d c; further is:

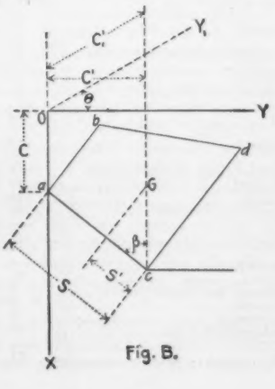


Fig. B.

$ab = p_n$ for $y = 0$,

$cd = p_n$ for $y = C'$, and

$\frac{d_y}{d_s}$ (Fig. A) $= \sin\beta$.

consequently

$$p_n = w \times \frac{(1 + \sin\varphi)(1 - 2\cos^2\beta)}{1 + \sin\varphi} \times \left(\frac{y}{\tan\beta} + C\right)$$

$$ab = w \times \frac{1 + \sin\varphi\,(1 - 2\cos^2\beta)}{1 + \sin\varphi} \times C$$

$$cd = w \times \frac{1 + \sin\varphi\,(1 - 2\cos^2\beta)}{1 + \sin\varphi} \times \left(\frac{C'}{\tan\beta} + C\right)$$

and

$$\frac{cd}{ab} = 1 + \frac{C'}{C\tan\beta}$$

The formula for the center of gravity of trapezoid (a b d c) gives

$$\frac{S'}{S} = \frac{1}{3} \times \frac{2 + \dfrac{cd}{ab}}{1 + \dfrac{cd}{ab}}$$

or

$$\frac{S'}{S} = \frac{1}{3} \times \frac{3 + \dfrac{C'}{C\tan\beta}}{2 + \dfrac{C'}{C\tan\beta}}$$

$$\frac{S'}{S} = \frac{3C\tan\beta + C'}{3\,(2C\tan\beta + C')} \qquad (2)$$

If O Y (Fig. A) is not horizontal, the formulas become more complicated; and in the special case of $\Theta = \varphi$:

$$N_1 = w\cos\varphi\left\{\sin\beta + \left(\sin\varphi + \frac{\cos\varphi}{\tan\beta}\right)\cos(\beta - \varphi)\right\}\left(\frac{C_1'^2\sin\varphi}{2} + \frac{C_1'^2\cos\varphi}{2\tan\beta} + CC_1'\right) \qquad (3)$$

and

$$\frac{S_1'}{S_1} = \frac{1}{3} \times \frac{3C + C_1'\left(\sin\varphi + \dfrac{\cos\varphi}{\tan\beta}\right)}{2C + C_1'\left(\sin\varphi + \dfrac{\cos\varphi}{\tan\beta}\right)} \qquad (4)$$

Formulas (1) and (2) will materially shorten the time for computing as compared with the strain sheets Figs. 1 and 2, (Eng. News, Sept. 23, 1897, page 196) of the designers of the coal bin at Paterson, N. J.; and the proposed theory gives, moreover, the distribution of the pressure, which is needed for finding the bending moment. I consider, however, the theory of Fig. 2 of the designers as an allowable approximation for computing the tension in the horizontal tie, with a proper factor of safety, but not as an assumption exaggerated on the safe side.

For this horizontal tie I would take a factor of safety of at least 8; because it is buried a great part of the time in a heap of wet coal, and the coat of painting cannot be relied upon as protecting against rust; it is further constantly exposed to surface damages and also liable to receive, in consequence of its shape, a bending moment from the overlying coal, for which it was not computed. The horizontal tie is, therefore, undoubtedly in less favorable conditions than a truss-member of a bridge. Another reason for taking the factor of safety for the horizontal tie higher than for the walls of the coal bin, is the fact, that the failure of one horizontal tie will increase the strains in the remaining parts of the structure and consequently cause the entire bin to collapse; while on the contrary the failure of a piece like M A will relieve the strain in a part of the remaining structure.

J. J. Israëls, C. E.

Denver, Colo., Oct. 8, 1897.

(Our correspondent objects to our assumption that the slope of maximum pressure is a frictionless surface. We perhaps did not make it clear that this was merely an assumption. We still think, however, that it is an assumption which should be made. The wedge of granular material that tends to slide down the slope of maximum pressure is probably retarded to some extent by friction; but that friction is a most variable quantity, and a slight jarring of the granular material, such as the vibration of machinery will produce, may reduce it nearly to zero. We believe, therefore, that the only safe assumption is that the wedge is free to slide down the slope of maximum pressure without friction.

Our correspondent further points out that only a normal pressure can be produced against a frictionless surface. This is, of course, correct, and is not contradicted in our article. It is always possible to resolve such a normal force, however, into horizontal and vertical components.—Ed.)

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ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 28. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

The paper in this issue by Col. N. H. Heft, detailing the experience of the New York, New Haven & Hartford R. R. with its third rail system of electric traction, is one of the most interesting contributions to our knowledge respecting the merits of electric traction for heavy suburban service that has appeared for some time. The advantages of the third rail system are pretty well known, as are the defects of flexible overhead conductors for supplying current to heavy trains, running at high speeds; but many engineers have been skeptical as to whether any surface contact system would not prove so dangerous to trackmen, yardmen, trainmen and others, and would not cause so large a loss of current by leakage as to make its adoption a doubtful expedient. Col. Heft's remarks on these points are, therefore, very welcome, and to many they will doubtless come as a surprise. This is especially true as respects the conditions existing in wet weather. According to Col. Heft, even when a section of the track was submerged in a heavy storm, so that the third rail and the track rails were under water, the leakage was "almost imperceptible." Bearing in mind that the third rail is only insulated by resting on short wooden posts soaked in an insulating compound, and that the distance from the track rail is only 2 ft., this is certainly a remarkable record. It may be best explained by remembering that the conductivity of fresh water is very low, and that metal surfaces immersed in water and transmitting current to it soon become covered with minute gas bubbles which form an excellent insulator.

But to most engineers the question of danger will appear, we believe, more important than the question of leakage of current. Upon this point also, however, Col. Heft's statements are most reassuring. He appears to have had no trouble with trackmen getting knocked down and bringing damage suits in consequence, and the prospect of legislative interference with the use of exposed conductors on the ground along a railway track doubtless appears to him to be too remote to be taken into consideration.

The advantages of the third rail system, and the fact that if steam railways are to compete with street roads they must copy to some extent street railway methods, are well set forth by Col. Heft, and we commend his paper to the careful perusal of our readers.

In our issue of July 8 we noted briefly the record made on the first run on July 2 of the Philadelphia & Reading's Atlantic City express train; but the complete record of this train's daily runs through July and August is such a remarkable and wholly unprecedented feat in fast express train service that it deserves a fuller notice. The copy of the train dispatcher's sheet before us shows that this train ran for 52 days, and its average time consumed from the start at Camden to the stop at Atlantic City, 55.5 miles, was 48 minutes. This is equivalent to a uniform rate of speed from start to stop of 69 miles per hour. Owing to delays on the ferry from Philadelphia to Camden the train was always from 1 to 4 minutes behind its schedule time in starting; but this lost time was invariably made up. With the exception of one day, when the arrival was made exactly on time, the stop at Atlantic City was made from 1 to 2¾ minutes ahead of the schedule. On July 14 the run between terminals was made in 46½ minutes, or at an average speed of 71.6 miles per hour. On 22 days the train was made up of 5 cars with a total weight of 320,300 lbs. On 30 days there were six cars, with a weight of 379,500 lbs. The locomotive was a Baldwin compound with a Wooten fire box and weighed with the tender 227,600 lbs. The passenger department of the Reading has issued a complete record of this wonderful performance, giving every detail, and we advise any of our readers who may be interested in the records of remarkable feats in railroading to apply for a copy to Mr. E. J. Weeks, the General Passenger Agent of the company, whose headquarters are in the Reading Terminal station in Philadelphia.

We know of no other record of fast regular train service that even approaches the above. In this country, certainly, an average running time of 69 miles an hour between terminals, day in and day out, is wholly unprecedented; and a table before us of fast English express runs, from 100 to 200 miles in length shows speeds of only 47 to 55 miles an hour. We congratulate the Reading officers on their remarkable feat.

Among the most notable things connected with the discussion of public ownership of municipal works are the glittering generalities liberally proclaimed by each party to the debate. It is true that some of the facts involved seem too obvious to require proof, and that where proof is plainly needed it is often difficult to secure it. But obvious as some ideas may seem to be, specific information generally modifies them to some degree; and difficult as it frequently is to obtain desired information, patient investigation will generally bring to light something of value.

It is commonly asserted by the opponents of municipal ownership that this system of controlling various classes of city works has proven, and is bound to prove, a failure, because of the uncertain tenure of office of the public servants in charge. So far as we are aware, no one has ever tried to prove or disprove this assertion, or to show what degree of truth or falsity it may contain. It has sometimes been urged in reply that with an increase in municipal functions the importance of putting and keeping the right men in office will be forced home on taxpayers and voters, and fitness and meritorious service rather than partisan activity or the possession of a "pull" will become increasing factors in the selection of city officials.

With the desire of throwing light on an important subject we have made a study of the tenure of office of one important class of city officials, the superintendents of city water-works, taking up for the same periods the superintendents of private water companies, by way of comparison. Our studies are based on the names of superintendents given in "The Manual of American Water-Works for 1897," compared with those in the "Manual" for 1890-1, and "The Statistical Tables of American Water-Works" for 1887 and 1883, respectively, affording approximately, 5, 10 and 15-year periods, on taking into account the dates of the returns for the several issues. The total number of names of water-works superintendents of both classes were 909 for the five, 399 for the ten, and 269 for the 15-year period, fair numbers, certainly, both in themselves and in proportion to the number of works in existence in the United States at the beginning of each period, there being described in the 1890-1 issue 2,037 water-works in the United States, against 1,328 in the 1887, and 750 in the 1883 issue.

The figures, as presented in the accompanying table, have been compiled by groups of states, in accordance with the classification followed in the "Manual," and which will be apparent from the group names.

For the whole country and for nearly all of the groups each of the three periods shows a greater permanency of office among the private than among the public works, but the difference is not so great as might have been expected, especially in the last two periods. For the first period 62 per cent. of the private and 46 per cent of the public works made no change in their superintendents. For the second period, of about ten years, no changes occurred in 39 per cent. of the private and 31 per cent. of the public works, while in the last, or 15-year period, the relative percentages were 34 and 23. The differences in these percentages of permanency for the successive periods were only 16, 8 and 11, respectively, in favor of the private companies. In general the Eastern and Southern groups of states make a better showing than the balance of the country for both classes of works, the men themselves, perhaps, having less tendency to change occupation or residence than in the West. In the New England states the public and private works make practically the same showing, and that a high one, for each of the three periods, while in the Middle group the private are far ahead of the public throughout.

Disregarding ownership, the percentages of works which retained the same superintendent are 55 for the first, 35 for the second, and 27 for the third period. Many of the changes on each side have been caused by death, a factor that could not be fully ascertained and so has been ignored. In many other cases of change of superintendent

Permanence of Tenure of Office Among Water-Works Superintendents for Approximate Periods of Five, Ten and Fifteen Years.

Groups of states.	Company. No change.	Company. Change.	City. No change.	City. Change.	No. reporting. Company.	No. reporting. City.	No. reporting. Total.	P. c. of no changes. Company.	P. c. of no changes. City.
Five-Year Period.									
New England	26	60	28	45	86	71	157	70	63
Middle	41	108	44	39	149	83	232	72	48
South Atlantic and South Central	31	31	15	14	62	29	91	50	48
North Central	36	48	73	44	84	117	201	57	38
Northwestern	26	28	24	15	54	39	93	52	38
Southwestern and Pacific	44	57	16	10	101	26	127	56	38
Total	204	332	198	167	536	365	901	62	46
Ten-Year Period.									
New England	19	14	29	24	33	53	86	42	45
Middle	30	35	45	20	65	65	130	54	31
South Atlantic and South Central	9	6	9	10	15	19	34	40	53
North Central	17	3	41	11	20	52	72	15	21
Northwestern	15	4	7	1	19	8	27	21	13
Southwestern and Pacific	22	10	17	1	32	18	50	33	6
Total	112	72	148	67	184	215	399	39	31
Fifteen-Year Period.									
New England	9	6	32	20	15	52	67	40	38
Middle	31	18	40	8	49	48	97	37	17
South Atlantic and South Central	4	4	9	4	8	13	21	50	31
North Central	5	2	36	4	7	40	47	29	10
Northwestern	7	3	1	1	10	2	12	30	50
Southwestern and Pacific	15	3	7	0	18	7	25	17	0
Total	71	36	125	37	107	162	269	34	23

some other official has retained a responsible position throughout the period. Altogether, then, our American cities are to be congratulated on the permanency of the management of their waterworks, and the difference between private and public ownership in this respect is not so marked as opponents of public ownership, and municipal reformers also, have urged, although there is plenty of chance for improvement in each respect. It is equally to be desired that good business management and permanency of office prevail under each plan. Unfortunately there are many conspicuous lapses in both cases.

EFFICIENCY OF A FOUR-STAGE AIR COMPRESSOR DELIVERING AIR TO A STORAGE RESERVOIR.

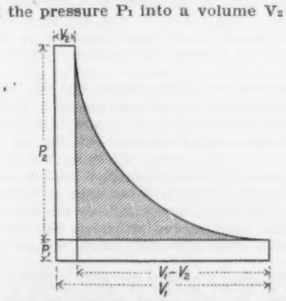
The records of the two tests of the four-stage Ingersoll-Sergeant Air Compressor, given in our issue of Oct. 7, contain statements of the several efficiencies of the machine known as the mechanical and the volumetric efficiencies and the "efficiency of compression," so-called, but they do not contain a statement of the total efficiency of the apparatus, defined as the ratio of the useful work done by the air cylinders to the indicated work of the steam cylinders. The computation of this total efficiency and the results derived from it may be of interest as a supplement to the records already published.

The useful work done by the air cylinders was the storing in a receiver of 925 cubic feet of air at a gage pressure of 170 atmospheres (or 170 × 14.7 = 2,499 lbs. per sq. in. above the ordinary atmospheric pressure), and at the temperature of the surrounding atmosphere. The measure of this work in foot pounds is the net theoretical amount of work required to perform the compression isothermally; that is, the amount theoretically required to compress the air at a constant temperature in a frictionless but air-tight cylinder, the heat due to compression being abstracted as fast as it is generated.

The amount of this work is easily calculated by means of the following formula:

Work of compression in foot lbs., $= P_2 V_2$ hyp. log. $R - P_1 (V_1 - V_2)$, in which P_1 = pressure in lbs. per sq. ft. above vacuum of the air before it is compressed; that is, the atmospheric pressure, or 14.7 lbs. per sq. in. = 2,116 lbs. per. sq. ft.; P_2 = pressure in lbs. per sq. ft. above vacuum after compression; V_1 and V_2 = volumes before and after compression, respectively, and R = the ratio of compression, or $V_1 \div V_2$. The term, $P_2 V_2$ hyp. log. R in the above expression is the total work of compression measured above vacuum, and the term $P_1 (V_1 - V_2)$, which is subtracted, represents the portion of this work which is done by the external atmosphere during the compression from the volume V_1 to the volume V_2.

In the accompanying diagram the net work (measured above the atmospheric pressure, or P_1) of the isothermal compression of air of a volume V_1 and the pressure P_1 into a volume V_2 and to a



pressure P_2 is represented by the shaded portion of the diagram. The rectangular area $P_2 \times V_2$ represents the additional work which would be done if the air, after being compressed to the pressure P_2, were delivered into a receiver maintained at the same pressure; but in the case of a test made by pumping air into a tank, in which the pressure gradually increases from P_1 to P_2, the only work done is the net work of compression represented by the shaded area.

In the test made by the Cornell students, only three of the four sections of the receiver were used for storage, or ¾ of 925 = 694 cu. ft. nearly. The figures to be substituted for the letters in the formula given above are:

P_2 = 171 atmospheres × 14.7 lbs. per sq. in. × 144 sq. ins. = 361,973 lbs. per sq. ft.

P_1 = 1 atmosphere, ¾ 2.166.8 per sq. ft.

V_2 = 694 cu. ft.

V_1 = 694 × 171 = 118,674 cu. ft.

R = $V_1 \div V_2$ = 171,

hyp. log 171 = 2.2330 × 2.3026 = 5.1417.

we have then for the net work done on the air:

361,973 × 694 × 5.1417 — (2116.8 × 694 × 170)
= 1,041,902,000 ft. lbs.

From a summing up of the indicator cards of the steam cylinders it appears that the total work of the steam was approximately 786 HP. hours = 786 × 1,980,000 = 1,556,280,000 ft. lbs. Dividing the net work done on the air by this gives an efficiency of 66.95%.

In the tests made by the Stevens Institute students, the whole receiver capacity of 925 cu. ft. was used. In the 400-minute test, compressing from 1 to 171 atmospheres, the figures for computing the net work done on the air are the same as those given above except that 925 is substituted for 694 cu. ft. The result of the calculation is 1,388,702,000 ft. lbs. The work in the steam cylinder averaged 153.75 HP. This, multiplied by 6⅔ hours, gives 1,025 HP. hours, or 2,029,500,000 ft. lbs., and the resulting efficiency is 68.42%.

In the second test by the Stevens students, in which in 90 minutes the pressure in the receiver was increased from 135 to 170 atmospheres, gage, the net work done on the air is the difference between the isothermal compression of 171 times the cylinder volume of air at atmospheric pressure into one cylinder volume at 171 atmospheres, and the isothermal compression of 136 cylinder volumes into one volume at 136 atmospheres. The larger quantity is that already found, 1,388,702,000 ft. lbs., and the smaller is calculated from the formula by making the following substitutions:

P_2 = 136 × 14.7 × 144 = 287,865 lbs. per sq. ft.

V_2 = 925 cu. ft., V_1 = 925 × 136 = 125,800 cu. ft.

R = $V_2 \div V_1$ = 136; hyp. log. 136 = 4.9127.

This gives 1,043,884,000 ft. lbs.; which, subtracted from 1,388,702,000, gives 344,818,000 ft. lbs. as the net work. The indicated work in the steam cylinders averaged 177.68 HP., or 266.52 HP. hours for the 90 minutes, or 527,710,000 ft. lbs. Dividing 344,818,000 by this gives an efficiency of 65.34%.

The three figures of efficiency thus obtained, viz., 66.95%, 68.42% and 65.34%, show a fairly satisfactory agreement. The third test, it will be noted, was made under different conditions than were the other two, the pressure in the receiver being high during the whole of this test, rising from 135 atmospheres at the beginning to 170 atmospheres at the end, while the other tests were begun with the air in the receiver at ordinary atmospheric pressure. The test made during the higher ranges of pressure would be expected to show a lower efficiency than those made over the entire range of pressures, on account of the probability of greater leakage at the higher pressures. The third figure, 65.34%, is the one which corresponds most nearly to regular working conditions of the apparatus, in which air is delivered into a receiver constantly maintained at a high pressure.

In the report of the test by the Cornell students (see page 237 of our issue of Oct. 7), the several efficiencies of the apparatus are given as follows: Mechanical efficiency, 90.4%; efficiency of compression, 88.9%; volumetric efficiency, 89.34. The product of these is 71.8%, a considerably higher figure than either of those obtained in our calculations based on the receiver pressure. We are unable to account for the difference except on the supposition that the indicated work of the air cylinders was not accurately measured. All indicator cards are liable to certain percentages of error, and there is an unusually large probability of error in the measurement of the indicated work in the second intermediate and the high pressure air cylinders, since the pistons of the indicators used in taking the cards were only of ¼ and 0.1 in. diameter, respectively; and the nominal scale of the springs were respectively 250 and 1,250 lbs. to the inch.

The method of computing the efficiency of the apparatus by comparing directly the work done in the steam cylinders with the work of storing the air in the receiver, measured by the volume of the receiver and the difference between the pressures at the beginning and end of the test eliminates the errors of measuring the work done in the air cylinders by means of indicator diagrams. By this method it is not at all necessary to take diagrams from the air cylinders, although such diagrams are valuable for determining approximately the proportions of work done in the several cylinders, the value of the water jackets and intercoolers in reducing the total work of compression, the mechanical efficiency of the apparatus, and the so-called efficiency of compression, or the ratio of the indicated work in the air cylinders to the theoretical work of isothermal compression.

It is fair to state that the efficiency obtained above is based on tests made when the plant was newly set up and running under conditions in some respects less favorable than those which may obtain when it has been longer in service. Considering this fact and the very high pressure to which the air is raised, the figures of efficiency above attained appear very creditable to the designers and builders of this remarkable compressor.

If we take the efficiency of air compression to 2,500 lbs. per sq. in. as 65%, some interesting changes will be necessary in the computations of the efficiency of compressed air traction, which were published in our issue of Oct. 7. We there presented a statement of this efficiency given by Gen. Herman Haupt, in which the efficiency of compression was assumed at 80%. Substituting 65%, the table which we gave in the first column of p. 233 would appear as follows:

	Per cent.
Efficiency of compression*	65
Net possible efficiency (65 × 42.5)	27.625
Doubling this by reheating, equals	55.250
Efficiency of motor	80
Net efficiency compressed air traction 55.25 × 80 =	44.2

* Of this 57.5% is lost in wire drawing to 100 lbs. pressure and 42.5% remains.

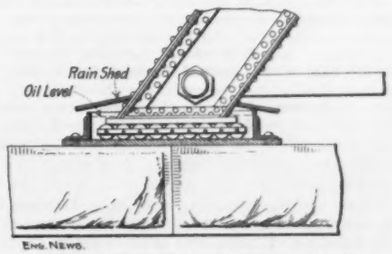
As we explained in our former article, the above computation makes no allowance for the cost of reheating the air; when this is taken into consideration it reduces the net efficiency to an even 40%, or, in other words, on the above assumption, which, it will be noted, includes motors which work with an efficiency of 80%, only 40% of the work done in the steam cylinders of the engines at the power station will be actually effective in propelling the car.

An additional bit of information as to the efficiency of present systems of compressed air motive power is furnished by the report, presented on another page of this issue, of the results of tests on a Hoadley-Knight motor car at Washington, D. C. This car seems to have consumed about 1,100 cu. ft. of free air per mile, while Gen. Haupt, in his letter on page 229 of our issue of Oct. 7, estimated only 2,000 to 2,400 cu. ft. per mile as the consumption of a compressed air locomotive hauling a train of five loaded cars weighing 130 tons. Apparently the Hoadley-Knight motors used in Washington must work with much lower efficiency than 80%, or else the appliances for reheating the air are defective.

LETTERS TO THE EDITOR.

A Suggestion for Expansion Bearings for Bridges.

Sir: In reading several of the recent numbers of your most excellent paper, I noticed several discussions of ex-



A Bridge Expansion Bearing Immersed in Oil.

pansion bearings for suspension and truss bridges. The general sense of the discussion was that there had not been an expansion bearing invented that did not rust or

corrode in a few years so as to be practically inoperative.

While thinking over the subject of expansion bearings the idea occurred to me that a bearing could be devised in which the rollers would be entirely submerged in ordinary lubricating oil, and protected by a roof so that the water could not enter and mingle with the oil. I enclose a sketch showing my idea on this subject. It would be inexpensive to build, and after once being installed one could be sure that the rollers were not corroded, so as to become inoperative. Hoping this may be of some use to the profession in general, I remain,

Respectfully yours,

S. P. Baird,

Supt. the Portsmouth Street Railroad & Light Co.

Portsmouth, O., Oct. 11, 1897.

A Large Concrete Bell-Mouth Inlet.

Sir: For the purpose of diverting the River Elan during the construction of Craig Goch dam, for the supply of Birmingham, a tunnel (internal diameter 17.5 ft.) has been driven through the hill-side.

The entrance to this tunnel consists of a concrete bell-mouth, whose section is semi-circular at the top and semi-elliptic at the bottom. The radius of the top is 12 ft., decreasing after 20 ft. to the ordinary radius of the tunnel—8.75 ft.—and the bottom semi-ellipse has thus a major axis of 24 ft. and a semi-minor axis of 8.75 ft., which gradually develop after 20 ft. into the 8.75-ft. culvert radius.

Thus we have approximately a bell-mouth 20 ft. long, tapering from 24 ft. to 17.5 ft. in diameter. Can you or any of your readers oblige me by informing me whether there are many such large bell-mouths in existence, and for what purpose? Yours faithfully,

M. B. Friedberger.

Elan Valley, Rhayader, Radnorshire, Oct. 16, 1897.

The Tropenas Process of Steel Making.

Sir: We have read the article on "The Carpenter Process of Making Armor Plate" in your issue of Sept. 16. We have nothing to say about the manufacture of armor plates or the costs of production of steel in the United States, but we are in the best position for confirming what Mr. Carpenter says about the quality of the steel made by the new process of steel making which he saw here and on the continent of Europe. The process is the invention of Alexandre Tropenas, of Paris, and has been seen at work here by at least half a dozen gentlemen from the United States who are interested in the steel and iron trades.

Monsieur Tropenas came to us in 1890 and asked us to put his ideas of steel making into practice. We consented, and put down a small experimental plant to his designs, the converter being only of 10 cwt. (1,120 lbs.) capacity, and the process was successful from the first operation. At present we have three 2-ton converters in constant work, and the British government has adopted the process (under arrangement with us) at the Royal Arsenal, Woolwich, where, since June last, the open hearth furnaces have been closed down. There is no deception about the Tropenas process, as you seem to think there is. Any grade of steel can be made by it, and there is no difficulty in making castings weighing either a few pounds (even ounces) each or 10 tons each. We have often accumulated in ladles five "blows" from two converters and poured the steel into molds in less than two hours from start to finish.

We don't know where you will find another process to match that, nor by which, with ordinary hematite pig iron, you can make steel castings to yield 30 tons (67,200 lbs.) tensile strength per square inch with 30% elongation in 2 ins. Enclosed are details of mechanical tests of steel castings (not forgings) produced by the Tropenas process at these works, many of which, you will observe, exceed the figures we have just mentioned. Monsieur Tropenas has now about a dozen installations in operation in Europe, and why steel founders in your country have not adopted the process long ago we cannot understand. It is not the characteristic of your people to neglect the "newest and best thing going." Not the least of the recommendations of the Tropenas process are the simplicity of the plant required and its inexpensiveness.

Edgar Allen & Co., Ltd.

R. Woodward, Managing Director.

Imperial Steel Works, Sheffield, England, Oct. 5, 1897.

(The enclosures accompanying this letter give records of tests on steel castings made by Messrs. Edgar Allen & Co., by the Tropenas process, and certainly show excellent results. It is stated that locomotive wheel centers, crossheads, truck center plates, crown-bars, etc., have been furnished to a large number of the principal railways of Great Britain and India, and to railways in Chili, Mexico, Natal, Japan, New South Wales and other countries. Tests from these castings are given showing an elongation of 30 to 35% in 2 ins., with a reduction of area of 50 to 55%. The firm is also making Belleville boiler castings, coupling hooks for railway cars, engine frames, etc., by this process. Another specialty is steel castings for electric dynamos and motors. Tests made by Prof. J. A. Ewing show that this steel has remarkably high permeability, and is very uniform, so that it forms, to quote Prof. Ewing: "an exceptionally good material for dynamo magnets."

Desiring to learn more concerning the steel making process by which these results are obtained, we have secured a copy of the American patent, No. 511,919, issued to Alexander Tropenas, Jan. 2, 1894, for a steel converter. According to the specification of the patent, the principal feature of M. Tropenas' process is that he avoids agitating the metal in the converter. In the ordinary Bessemer converter, as most of our readers are aware, the blast of air is forced through tuyeres in the bottom of the converter, and the whole of the interior of the converter is a seething mass during the blow. This has always been considered a necessary feature in order to bring the air in contact with all parts of the molten metal and rapidly oxidize its impurities. Concerning this M. Tropenas says in his specification:

The object of this (the special arrangement of the tuyeres which he adopts) is to prevent all gyrating, churning or stirring movement in the molten bath. The object in avoiding this gyrating, churning or stirring movement is to prevent the slag being constantly stirred with the molten metal, which in consequence of this stirring being done in an atmosphere containing a great proportion of the reductor gas (C O) causes, to a great extent, the impurities in the slag to return again into the bath and thus undo a great deal of the purifying work which has previously been done by the action of the air from the bottom tuyeres. * * * * * * It may here be observed that the most impure steel manufactured by the pneumatic process is that produced from a bath which has received the largest amount of gyrating, churning or stirring in its molten state.

In the Tropenas converter, the tuyere openings are always above the surface of the metal, and they blow across its surface. Another novel feature is the heating of the air used for blowing. This is done by a regenerative process. Part of the hot gases escaping from the mouth of the converter are drawn down and passed through checkerwork, and by passing the entering air over the checkerwork it is given a high temperature.

Still another feature for which claims are made in the patent is the use of an independent set of tuyeres above the "refining" tuyeres as they are called. Air is admitted through these upper tuyeres in just sufficient quantity to burn the carbonic oxide resulting from the purifying process to C O_2. This is claimed to give a very high temperature in the top of the converter, and to increase the temperature of the molten bath. The claims made by the inventor for his process are summarized in his specification as follows:

(1) A special form of the bottom of the converter so as to obtain a great depth of the molten bath in proportion to its cubical contents and surface area at the top on which the air from the bottom tuyeres has to act and prevent to a certain extent the movement of the metal which always takes place in other pneumatic processes in which the depth of the metal is shallow; (2) a special disposition of the tuyeres projecting beyond the face of the lining, which co-operate with (1), already named to keep the bath comparatively placid or quiet, and which disposition is not used in other pneumatic processes; (3) the circular form of the face of the tuyeres to prevent the simultaneous obstruction or corking of all the tuyeres, and to give the operator an opportunity of moving the converter if the bottom tuyeres have been put too near the surface of metal during the first period, and this disposition of the tuyeres is totally different from that in other processes; (4) symmetrical position of tuyeres from the center tuyere to prevent any gyrating motion of the bath, and thus being different to other processes where the tuyeres are placed at such an angle as to produce a gyrating motion; (5) special position of the bottom tuyeres so that their ends come always above and never under nor in direct contact with the metal, a position totally different from other processes where the tuyeres come more or less below the surface; (6) oxidation of the elements, which elements have to be eliminated from the iron, at the surface of the bath only, and the reaction being transmitted from molecule to molecule from the surface throughout the bath to the bottom of same without any stirring movement and mixture of slag with the metal; (7) addition of a second or top row of tuyeres parallel, or otherwise, with the bottom tuyeres and through them to supply air for the combustion of C O and H and increase the temperature of bath by the utilization of gases completely lost or other pneumatic processes, and to regulate at will by means of a valve the volume of air necessary for the combustion of C O and H and doing this without interfering with the action of the bottom tuyeres; (8) utilization of a portion of the hot gases from the converter to heat the air coming from blowing engine to tuyeres; (9) facility to repair the lining of converter by opening the door placed at the bottom; (10) obtaining very pure steel as the slag and metal not being stirred or mixed together the impurities from the slag do not get back into the metal, also, obtaining steel of very high temperature so as to admit of its being taken away from the converter in small quantities; (11) suppression of projection of metal and slag out of the converter during the process; (12) diminution of waste by reason of bath being kept comparatively quiet and by reason of the particular method of blowing herein previously described whereby less oxide of iron is made; (13) less destruction of lining by reason of less oxide of iron being made; (14) less final addition being required on account of the steel being pure and more free from oxide of iron in solution; (15) reduction in cost of the steel by reason of (a) less waste of iron during operation; (b) less destruction of lining; (c) less final addition.

(We give thus fully the claims made by M. Tropenas for his process; but we must confess that we have still to be convinced that his theories are well grounded. The idea that impurities eliminated from the metal become again mixed with the bath by reason of the agitation it undergoes is not new. That was one of the claims made for the old Robert converter, in which the air was admitted just below the surface of the bath. The comments of Dr. Henry M. Howe, in his "Metallurgy of Steel," on the Robert process are so apropos as comments on M. Tropenas' claims that we venture to reprint them as follows.—Ed.)

As far as I can make out, the idea is that in bottom-blown vessels "the impurities" eliminated from the cast-iron become mixed up with the iron, while in the Robert vessel they do not. First, bottom-blowing is not essential to the Bessemer process: the earlier successful vessels were blown from the sides. Rotary motion was infused in a way closely similar to that of the Robert "process" by setting the tuyeres semi-tangentially. High-side blowing was adopted long ago by Durfee, and later by Clapp and Griffiths. Here, then, is no novelty. It is claimed, apparently, that restricting the blowing to one side of the vessel leaves the impurities in a quiescent state on the leeward side of the vessel, while if the blast enters on all sides this repose is lost.

What, now, are these impurities eliminated during the process, whose return is to be dreaded? Gases, which rush out of the vessel's nose; slag, which cannot be made to unite with the iron by any possibility; iron oxide, the purifying substance itself, licked up voraciously by the slag, probably wholly removed by the recarburizer.* Where is the evidence that injurious impurities, removable by such purely mechanical means, exist in Bessemer steel, or that one-sided blowing furthers their removal? What is the reason to expect that it should? Shall inventors next patent stirring porridge to left instead of right; methods of making wood float and lead sink?

The chief advantage claimed for the Robert over the common converter is that it yields a better product and a higher temperature, so that it can be used advantageously for making small steel castings. The present evidence that its product is superior is of the usual wholly unsatisfactory kind, and merits neither presentation nor rebuttal.

I have seen nothing in the many castings which I have seen, made from the Robert vessel, which indicates that an extraordinarily high temperature is reached; some of them were doubtless cast at a decidedly high temperature, yet not higher than can be readily attained in common vessels. I am sure that the temperature in the vessel when it was turned down after the blows which I have seen was not higher, and I think that it was decidedly lower, than that of the common vessel at the end of a normally hot below, and so said an eminent metallurgist who was with me. Yet the conditions at hand should have insured an unusual temperature even in the common vessel, for the cast-iron was an unusually "hot" one, containing 2.4% of silicon, 1% of manganese and 3.75% of carbon; the walls of the vessel were unusually thick, about 16 ins., I was informed; and the vessel was recarburized with only 1% of ferromanganese, so that the chilling effect of a large recarburizing addition was avoided.

Suppose, however, that we concede that an unusually high temperature may be reached, thanks to these precautions, to the combustion of an excessive proportion of the iron of the charge (it is admitted that the loss is 15%, and, judging from the amount of smoke, and from the well-known tendency of the siderurgical mind to persuade itself that the loss is much lower than it actually is, I should put the loss at nearer 18%, or say half greater than in common vessels), and perhaps to the combustion of an unusually large proportion of the carbon to car-

* During casting, when metal and slag become cool and viscid, there is indeed danger of their becoming mixed. But this danger is not lessened by keeping them separated during the blow while molten, for then they separate automatically and need no aid. It is mixing during and immediately before their pouring, and not during the blow, that we should avoid.

The oxide of iron is the purifying substance itself, to borrow the language of the quack. It is by oxide of iron that the carbon, silicon and manganese are removed. To prevent oxide of iron from impregnating the bath, if it were possible, were to arrest the process. Now, it is only the last traces of iron oxide that can remain mixed up with the molten metal during the blow. The great bulk of it either oxidizes carbon, etc., or separates by gravity from the metal, which is able to dissolve but a minute portion of it. As this minute portion must be and is mixed up with the metal in the Robert vessel, it profits nothing to attempt to keep the rest of the iron oxide from the metal. Such propositions do not deserve serious consideration.

bonic acid, due to introducing the blast near the top of the bath—admitting all this, what follows? That these same conditions can be reproduced in the common converter, by inclining it so as to bring some of the tuyeres near the top of the bath, as has long been habitually done in the case of unduly cold heats.

But as this is not patentable, while the mysterious gyrations, moderation and regulation of currents, and atomizing stripping action seems to be, the cynic readily surmises why the former simpler explanation is less palatable to the promoters of the Robert process than the latter, which, foggy, mysterious, incomprehensible, is certainly of the kind which, rightly or wrongly, we involuntarily associate with charlatanry and imposture. Therefore, while I believe that M. Robert is quite sincere, though clearly mistaken, as to the rationale of the effects of his particular modification of the Bessemer converter, it seems well to warn the public that wholly disinterested experts regard the extravagant statements of the promoters of his process (?) most incredulously, and are most skeptical as to its possessing any real value.

Notes and Queries.

J. M. is informed that all communications must be accompanied by the name and address of the writer in order to receive the editor's attention.

EXPERIENCE WITH ELECTRIC TRACTION ON THE NEW YORK, NEW HAVEN & HARTFORD R. R.†

By Col. N. H. Heft.*

The New York, New Haven & Hartford R. R. Co. owns and controls about 2,800 miles of main line railroad track in New York, Massachusetts, Rhode Island and Connecticut, of which about 16 miles are operated by electricity on the third rail system and 14 miles on the overhead trolley system.

The company also owns the entire capital stock of the Stamford Street Railroad Co. and the Meriden Electric Railroad Co., the former operating about 10½ miles of track, and the latter about 17½ miles on the overhead electric system.

About three years ago the company found that various electric railways in its territory were gradually extending their operations into the field of interurban work, and that the company's passenger earnings were suffering accordingly. It was at once seen that by no ordinary methods of changing schedules or increasing speeds could this lost traffic be won back again, and, with characteristic knowledge and courage, President Clark and the New Haven directors determined to "steal the thunder" of its new competitors, and commenced a series of elaborate experiments in heavy electric railroading. It must be confessed that this decision was reached only after some misgivings. To the average railroad man street railways have, until recently, seemed a pretty sort of toy, fit for apprentices in the art of transportation. Latterly, however, he has waked up to the fact that "the tail will wag the dog" unless some radical action is taken, particularly in suburban and short-distance work.

The first line to be equipped by the company was a purely summer road, operated for about four months in the year on the Massachusetts coast from Nantasket Junction to Pemberton, a distance of about seven miles of double track. This line was chosen partly because the main line operation would not be interfered with in case of trouble with the electric trains and partly because of the heavy summer traffic which would put the new apparatus and the feasibility of the entire system to a severe test. An overhead trolley line was built, with center pole construction, and everything made very strong and more substantial than was at that time found in any street railway work to our knowledge. At the time of construction of this overhead line there were no suitable movable switches in the market, and we had to remodel and have built especially for our purpose those which we finally adopted. The overhead switch was connected with the track switch in such a way that both are controlled by a single lever at the switch stand.

The line was operated for the first summer with excellent success and, all fear of trouble having disappeared, an extension of 3.6 miles was made on the main line of the company's Plymouth Division, from Nantasket Junction to East Weymouth, this section being operated by the third-rail system.

In December, 1896, we commenced work on a new line running from Berlin, Conn., through New Britain to Hartford, a distance of 12.3 miles, 3 miles of which, from Berlin to New Britain is a double track, and the remainder, from New Britain to Hartford, a single track. A power station was built at Berlin, one end of this line, partly because of a desire to test transmission of power to a considerable distance, and partly because Berlin is the center of several radiating lines which may eventually be put into operation by electricity.

Train Service and Traffic.—We have learned very thoroughly, in our street railway experience, the lesson of the importance to any transportation agency, working in a thickly populated territory, of uniform fares and a frequent and regular train service, one which requires no printed schedule to enable people to know when cars may be found in waiting. The time has come when every progressive railroad manager must recognize that new conditions and the new character of competition requires a complete change of operating methods.

On its Nantasket Beach line, the New Haven Company gave, during the last summer, a regular half-hour service from 6.30 in the morning until 11.30 at night. When unusually heavy boat loads arrived at Pemberton from Boston, trains were run in as many sections as was found necessary to take care of the people, but still the half-hour schedule was not departed from on ordinary days. On Sundays and holidays, when boats arrived at Pemberton every 15 minutes during the greater part of the day, express trains between Pemberton and Nantasket were sandwiched in between accommodation trains in such a way as to give a 15-minute schedule of alternate express and accommodation trains. The time-table this summer required 33 regular trains daily, each way, between East Weymouth and Pemberton. During July and August the traffic increased to such an extent as to require six motor cars in constant week-day service, and on Sundays and holidays 11 motor cars have frequently been called for.

The fares charged on the Nantasket Beach line before the advent of electricity were 10 cts. from Pemberton to Nantasket and 18 cts. from Nantasket to East Weymouth, a total of 28 cts. from Pemberton to East Weymouth. With electric traction they have been placed at a uniform rate of 5 cts. from Pemberton to Nantasket and 5 cts. from Nantasket to East Weymouth, a total of 10 cts. from Pemberton to East Weymouth. Under these new conditions the traffic has increased enormously on this line; the summer of 1895, the first of electrical operation, showing an increase of 92.6% over the previous summer in the number of passengers carried; the summer of 1896 showing 45.1% increase over 1895, while, in the summer just passed, we have carried nearly three times as many passengers as in the last year of steam operation.

The operation of the line from New Britain to Hartford was commenced in May last, with a regular half-hour train schedule from 6 in the morning to 11.30 at night, and with a uniform fare of 10 cts. each way, instead of 23 cts., the former charge. The electric line carries through passengers only between Hartford and New Britain, the passengers for the five way stations being carried by the regular steam trains running on a parallel track. For ordinary every-day service, a single open motor car was used during the past summer, while for extra loads, light double-truck trail cars, seating 70 people were attached. On rainy days a standard closed passenger coach was hauled by the open motor car. On holidays and Sundays, the cars pulled two trailers, the entire train seating nearly 250 passengers. About the middle of August, steam service on the Berlin-New Britain Branch was discontinued, and traffic has since been handled entirely by electricity. Sixteen trains each way per day are run, connecting with steam trains. Under the conditions named on the Hartford-New Britain line we have carried, during the three summer months, 400% more passengers than we carried in the corresponding months of last year.

Speed, Acceleration and Schedules.—I do not suppose that any but a trained railroad man can understand the impossibility of operating trains and maintaining schedules by steam locomotives in the way that has been done by electricity at Nantasket Beach this summer. There are a great many curves on the line, and several grades, but there are none excessively sharp or steep, and it is not here that the trouble has come. The difficulty is found in the fact that there are no less than 17 stations on a line only 10.6 miles in length, or an average distance between stations of but about 0.6 of a mile. To make a run of 10 miles with 16 stops in 26 minutes; to be obliged to do this in order to connect with boats arriving at regular half-hour intervals and to keep out of the way of frequent regular steam trains on the main line of the Plymouth Division; to allow but four minutes at each end for unloading, switching (including running around trail cars), and loading; and to do this day in and day out, in regular service, through an entire summer; these are things which cannot possibly be accomplished by steam locomotives.

Now the reason why electricity can do this and steam cannot, is found in the tremendous accelerating power of properly designed electric motors, with rotary motion as compared with reciprocal motion of steam locomotives. On this line, for example, a 60-ton train, in running from Windermere to Allerton, a distance of only 1,800 ft., reaches a maximum speed of 31 miles per hour, while in the longer run, from Power Station to Nantasket Junction, a distance still of but 5,808 ft., a maximum speed of 39 miles is reached. The entire distance is covered, in regular service, at an average speed of 24.6 miles per hour, including stops.

Between Hartford and New Britain, the 9.3 miles distance is covered regularly by motor cars with two trailers in from 18 to 20 mins., an average speed of from 28 to 30 miles per hour, which, with a special high-geared motor, a maximum speed of over 60 miles has been made; the entire distance of 9.3 miles being covered in 10 mins. On this section a 52-ton train often reaches a maximum speed of 50 miles per hour. The current is cut off at 29 grade crossings when single-car trains are run. It is worthy of note, in this connection, that the line between New Britain and Hartford is in direct competition with a trolley line between the same points, but following a more circuitous route. The schedule time of trolley cars is 55 mins., as against our time of less than 20 mins., and the rate of fare is 15 cts. (including a transfer given for use on the street railways of either city) as against ours of 10 cts. for the straight run between the two cities only. The ownership of right of way has a very important influence upon speed and competitive conditions under circumstances like these.

Cars and Equipment.—The type of car selected for any good transportation service has a direct bearing upon the development of traffic and maximum gross receipts. It has been difficult for steam railroads to depart far from the long established custom of closed passenger coaches of the present standard type and to adopt open cars, on account of the disagreeable effect on passengers of the smoke and gases from engines. This has naturally thrown a great deal of traffic to competing street railway lines running open cars in summer, on account of the much greater pleasure in riding.

With electric operation, open cars in heavy railroad practice are possible, even at considerable speed, particularly if the front of the car is closed in with glass, and both at Nantasket Beach and on the Hartford-Berlin line, we have used heavy open cars with great success.

The motor car which we have so far used we do not consider by any means the final type, and even now we have in mind plans of combination cars which we believe will be on the whole well adapted for railroad work. The present motor car is very heavily built, with floors of a height equal to that of our standard passenger coaches. It contains 16 cross seats, capable of seating 96 passengers, and the entrance is from either side with three steps. Each car has two heavy railroad trucks, one of which is equipped with two 125-HP. motors. The total weight of the motor car is 32 tons, and the trailer car of the same type weighs 25 tons. The motors which we have used up to date have been of a type common in heavy elevated railway work. These motors have often been in service for several consecutive days, making 324 miles each day, without apparent injury. We found the motors we are using already in the market when we commenced our experiments, and until recently no attempt has been made by us to specify changes. Under these circumstances, great credit is due the manufacturers for their efforts to meet the difficulties encountered. The experience gained with these motors has served as a basis for building larger and heavier types, better adapted for the severe work which they will be called upon to fulfill to meet our requirements. An important point which we shall specify in new motors is that they shall have the most perfect ventilation possible. The efforts of manufacturers have been hitherto directed towards completely encasing the motors, so as to make them waterproof, but in doing this ventilation has been sacrificed. We have found it beneficial to blow out our motors several times during the day by means of a blast of air from a hose pipe connected to our air brake reservoir, but this is, at best, but a makeshift.

It is very difficult to dispose of all the necessary cables, wires, brake rods and chains, air brake cylinders and apparatus, switches and other car controlling mechanism in the limited space beneath the car floor, as may be readily imagined by those familiar with street railway work. As a consequence, there has always been more or less controversy between those responsible for the placing of the different portions of the equipment, as to who shall have the first right to a given space, perhaps hardly half a dozen square inches in section. There is also more or less trouble with abraded wires, short circuited shoe hangers, etc., and for our future work, we are making an effort to simplify this mass of equipment mechanism by putting some of it, particularly the wires and cables, in a space between the true floor of the car and a false floor several inches below, specially provided for the purpose.

For operating heavy trains of his character, where currents of from 500 to 1,000 amperes are sometimes used, the controlling apparatus must be massive and strong in every part, and the greatest care must be taken to prevent arcing. We have had no trouble with controlling apparatus on our regular equipments, and we consider this branch of the apparatus well perfected.

The danger to station and car apparatus from lightning discharges, which is so important a factor in street railroading where the overhead system is employed, is avoided in third-rail work, since the third rail is so close to the ground. The problem of braking, which is so important a one in street railroading, is found more so with us since the train weights and speed are enormously greater. The regular Westinghouse air brake system, with engineer's valve, is used on our electric trains, but instead of steam air compressors, we have an electric motor compressor, controlled by an automatic regulator which has given excellent satisfaction.

†Condensed from a paper read at the annual convention of the American Street Railway Association, at Niagara Falls, N. Y., Oct., 1897.

*Supt. Electrical Department, N. Y., N. H. & H. R. R.

Our experience with trolleys on the overhead line at Nantasket Beach, originally put in two years ago, has not been satisfactory. We find it quite impossible to prevent the destruction of trolley wheels by almost continual arcing when attempting to take from the wire the heavy current required in starting and during acceleration, as well as the smaller currents taken at the maximum speed. There has been a good deal of trouble, moreover, in keeping the trolley on the wire in making speed and taking curves, and many trolley poles have been broken. The trolley difficulties have not interfered with the continuous operation of our line, but the cost of replacing wheels and poles has been rather large.

These difficulties have had an important influence in causing us to reach a decision in favor of the third rail. The contact shoes which take the current from the rail to the motor circuit have given, on the whole, good satisfaction, although they are occasionally carried away by the approach blocks at grade crossing when these blocks happen to be slightly misplaced so that the shoes strike them at the wrong angle. The contact shoes are suspended by cast-iron links, which are intended to be weak enough to allow the shoe to break away easily without doing damage to the framework of the car. The trail cars are also equipped with shoes and connected with the circuits on the motor car by means of flexible couplings, and it is possible, therefore, when the cars are run in trains, to bridge the longest gaps found at grade crossings and switches, so that it is not necessary to turn the current off on approaching these. This arrangement makes our trail cars independent of the motor car for heating and lighting. It should be noted, perhaps, that the Nantasket motor cars have two trolley poles, as well as contact shoes, and the changing from trolley to third-rail simply means the pulling down of the pole and the closing of the third-rail switch.

Third-Rail and Return Circuit.—Our third-rail and return circuit experience will perhaps be of value to both street railway and railroad managers, as we have undoubtedly made a wide departure from established methods, and have solved a number of interesting problems.

First is the question of insulation. The third-rail has a potential of 600 volts above the ground and rests upon creosoted wooden blocks dowelled into the ties, its eaves being only 1⅝ ins. above the tie.

We aim to so connect our third-rail lines and the service rail return as to have a practically complete metallic circuit of extremely low resistance; as far as possible, disconnected with the ground. We do not believe in grounding our track, and, though ground plates are placed at the station, connected to our generator, by far the largest proportion of the return current comes through the cables connected directly with the track, the percentage coming from the ground plates being extremely small.

The joints of the third rail are bonded by long copper plates, firmly bolted to both sides of the joint, 16 bolts being used in all. These copper plates are tinned before being put into position. Owing to the large area of contact surface, the presence of rust on this surface does not materially interfere with the conductivity of the joint, as shown by accurate tests.

The service rails are bonded with the greatest care, four copper leaf bonds, having a cross section of copper equal in conductivity to that of the rail, being used. These bonds are inserted in the base of the rail instead of the web, so as to prevent breakage through play at the joints. The copper leaves are cast into end piece blocks in such a way as to weld them thoroughly together in the blocks. The latter are formed into a hollow cylinder, 1 in. in diameter, which passes through a hole in the flange, and by which a large area of contact is secured. Tapered pins are driven into the inside of this cylinder from the top of the flange, and the connection made is very perfect. Careful tests have shown that the joints of both third and service rails have now a slightly greater conductivity than an equal length of the rails themselves.

A few words about the danger of the third-rail system would be, perhaps, in order. There have been many cases of people who have stepped from the ground to the third rail without feeling the current, and anyone can step upon it from a dry tie without the slightest effect. On all except wet days, our employees work about it without trouble, avoiding, of course, putting themselves in direct contact with both service and third rails, but not infrequently "monkeying" with the current in such a way as to get shocks of more or less severity in a sort of horse play. On wet days they refer to the third rail as being "lively," and are inclined to let it alone. Many of our employees have, however, received the heaviest shock possible to obtain, time after time, and care little about it, though those who are more influenced by electric shocks than others are sometimes thrown off their feet, but recover fully in a few minutes. We do not say that the third rail has no dangers, but we do not consider the danger as being at all serious or one which should interfere with the extension of the system.

As a result of the exceptional care which we have taken in bonding our third and service rails, we have found it unnecessary, in any third-rail work so far done, to use copper feeders, in spite of the fact that we are obliged to transmit current from Berlin to Hartford, a distance, as before stated, of 12.3 miles, straight away from the power station. This work is made up as follows: from Berlin to New Britain, a distance of 3 miles, there is a complete double-track electric road with two 100-lb. third rails and four 74-lb. service rails, all most carefully bonded as described above. From New Britain to Hartford, a distance of 9.3 miles, there is one complete electric track, with 100-lb. third rails and 70-lb. service rails, all carefully bonded, in addition to which we have connected to the service rails of the electric track the rails of the second track, paralleling this the entire distance, at various places, in order to get the benefit of whatever conducting power there might be in this track connected only by its fish plates at the joints. As a result of this work, we are able to run two trains of 52 tons each on the New Britain and Hartford line with an average loss of but 26½%. The current output of the station at such a time averages about 300 amperes, with a maximum flow of about 700 amperes at a pressure of 600 volts. Of course, if the service were heavier, so that more cars would be required, it would undoubtedly be necessary to reinforce the third rail with feeders.

Cost of Power.—In our Nantasket Beach station we have installed two engine generator units of 800 HP. and 550 K-W. capacity each. On heavy days both these engines are required, but on ordinary days but one only, and this is not fully loaded; the average loads being perhaps one-half the maximum.

In the Berlin station we have installed two engine generators of 1,200 HP. and 850 K-W. each. One unit only is required in the practical operation of all the cars on the Berlin and Hartford lines, and the average power output is hardly one-fourth of the maximum capacity. In both stations our aim has been to provide apparatus proved by long experience to be of the most simple and durable character.

We are now running our Nantasket plant condensing and our Berlin plant non-condensing, the loads in the latter being too light to make condensing profitable.

In spite of the fact that these general conditions of operation do not point to a low cost of power, because of the fact that we are working neither station at anywhere near its full capacity, I suppose we are, as a matter of fact, producing power more cheaply than can be done in any power station in the country using coal as a fuel, the reason being that we are burning sparks. "Sparks," as we are accustomed to call them, are the half consumed coal dumped from the extension front of locomotives at the company's various round houses. Nevertheless, there is a great deal of steam generating value in these sparks, as we have found by experience, and they are being carried on the company's cars to our stations at Berlin, Nantasket and Stamford, and charged to the electrical operation at the cost of freighting (including the usual profit to the company for transportation), plus the cost of loading and unloading, a total charge of 70 cts. per ton, delivered.

In order to burn these sparks, we are obliged, of course, to make some changes in the furnace arrangements, chief among which is provision for the introduction of live steam under the grates, forming a blower or forced draught. We originally supposed that some form of shaking or self-cleaning grate would be necessary in burning sparks, but have found in practice that, with ordinary grates, together with the steam blower, there is no difficulty. Of course, we have to use a greater weight of this half-consumed coal than would be the case with new coal, but still the economy is great, as a good quality of run-of-mine coal costs us in Connecticut about $3.00 per ton, delivered at power station.

A few figures as to the cost of power at Stamford may be of interest. This station furnishes current for our street railway system at Stamford and for lighting our railroad stations with 350 incandescent lamps. We are operating one engine only, of 500 HP. total capacity, direct connected to one 300 K-W. generator. For the first six months of full operation with sparks only, the total cost of fuel for this station amounted to 3 mills per HP. hour or 4 mills per K.-W. hour. For so small a station and one where the average amount of power developed is hardly more than one-third the rated capacity of the engine, I believe this to be a low figure. We have recently made, for our own information, for use in larger plants, special tests of the cost of power developed in this way, using for this purpose a water rheostat, in order to load the engine up to more nearly its full capacity. As a result of these tests, we find the cost of fuel for power, with the use of coal, to be 3.2 mills per HP. hour or 4.2 mills per K.-W. hour. With the use of sparks, the cost is reduced to 1.9 mills per HP. hour or 2.5 mills per K.-W. hour.

At our Nantasket power station this season the cost of fuel, with the use of coal, has averaged 4.2 mills per HP. hour or 5.6 mills per K.-W. hour, while with the use of sparks the cost has been 2.1 mills per HP. hour or 2.8 per K.-W. hour.

As before stated, our Berlin plant has not been run as economically thus far as it will be when a greater load is put on the engines and it will seem to be in the interest of economy to run compound condensing. At this station the cost of fuel, with the use of coal, has been 9 mills per HP. hour or 12 mills per K.-W. hour. Using sparks as fuel has reduced this cost to 3 mills per HP. hour or 4 mills per K.-W. hour.

It is very difficult, of course, if not impossible, to make any direct comparisons between the cost of motive power for electric railroading and that for steam railroading, on account of the different way in which the trains are made up. The best criterion would be the cost of motive power per ton mile hauled, but even here the results would be of little value on account of the wide difference in conditions, and, as a matter of fact, we have never attempted to make such comparisons.

There will always be room, doubtless, for railroads of two characters, the one operating on a purchased right of way, where trespassers can be kept away and high speed obtained, and the other operating on streets and highways, where passengers can be taken up and let off at their own doors. It is possible that, in some thickly settled districts, such as are found in New England and the Middle States, where popoulation groups almost touch each other, these two classes of service may occasionally be performed by the same agency, but there is no reason, ordinarily, why there should not be the most amicable and friendly relations, and not infrequently of a business character, existing between steam railroad and street railway companies.

THE FREQUENCY OF TORNADOES IN VARIOUS PARTS OF THE UNITED STATES.

In the June issue of the government "Weather Review" the tornado frequency per unit area is deduced from the best available records of the Weather Bureau. The area of the path of the tornado is the product of the length of this path by its breadth, and the statement is made that the area of destruction rarely covers more than 25 sq. miles. Owing to the extremely local character of the destruction the records become imperfect in proportion to the sparseness with which the country is settled; and in the newer states the apparent increase in the number of tornadoes is due entirely to the increase of population, and, consequently, more complete records. For Kansas and Nebraska, for example, the records relate almost entirely to the eastern half of these states. The accompanying table, notwithstanding its evident imperfections, due to the incomplete data from which it is compiled, is considered to be of considerable value.

In this table the third column contains the observations of Lieutenant Finley for the eight years 1874-1881, and the fourth column contains similar data for the years 1889-1896, as collected by A. J. Henry and published in the annual volume of the Weather Bureau. To these the editor of the "Review" has added, in the second column, the area of the respective states as expressed in units of 100 miles square; and also the columns of resulting averages.

The table shows that even in the so-called tornado states, the probability that any area of 100 miles square will be visited by a tornado in any year is less than certainty, or unity, or less than 100%. If the larger area be divided into areas 10 miles square the chance that some one of these smaller areas will be visited by a tornado within a year, is less than 1%; and the chance that any specific one of these small areas will be so visited is only 1% per century. For any specific area one mile square the probability is much less than one-sixteenth of 1% per century; and the probability that a given house will be destroyed by a tornado is far less than the probability that it will be destroyed by lightning.

Tornado Frequency.

States.	Area in units of 10,000 sq. miles.	Total number of tornadoes— 1874-1881, Finley.	1889-1896, Henry.	16 yrs.	Annual average— Per state.	Per unit area.
Alabama	5.1	12	13	25	1.56	0.30
Alaska	51.7	0	0	0	0.00	0.00
Arizona	11.4	2	0	2	0.12	0.01
Arkansas	5.2	8	18	26	1.62	0.31
California	15.8	1	0	1	0.06	0.00
Colorado	10.4	1	1	2	0.12	0.01
Connecticut	0.5	2	0	2	0.12	0.24
Delaware	0.2	0	0	0	0.00	0.00
Dist of Columbia	0.0	0	0	0	0.00	0.00
Florida	5.9	5	1	6	0.38	0.07
Georgia	5.8	29	12	41	2.56	0.44
Idaho	8.6	0	0	0	0.00	0.00
Illinois	5.5	50	29	79	4.94	0.90
Indiana	3.4	24	7	31	1.94	0.57
Ind. Ter. and Okla.	6.9	1	13	14	0.88	0.13
Iowa	5.5	26	28	54	3.38	0.61
Kansas	8.1	55	47	102	6.38	0.79
Kentucky	3.8	5	11	16	1.00	0.27
Louisiana	4.1	11	7	18	1.12	0.28
Maine	3.5	3	3	6	0.38	0.11
Maryland	1.1	8	3	11	0.69	0.63
Massachusetts	0.8	7	1	8	0.50	0.62

Michigan	5.6	13	5	18	1.12	0.20
Minnesota	8.4	21	22	43	2.09	0.32
Mississippi	4.7	9	15	24	1.60	0.32
Missouri	6.5	40	16	56	3.50	0.54
Montana	14.4	1	0	1	0.06	0.00
Nebraska	7.6	14	22	36	2.25	0.31
Nevada	11.2	1	0	1	0.06	0.00
New Hampshire	0.9	3	0	3	0.19	0.21
New Jersey	0.8	5	6	11	0.69	0.86
New Mexico	12.1	1	0	1	0.06	0.00
New York	4.7	20	5	25	1.56	0.33
North Carolina	5.1	14	2	16	1.00	0.20
North Dakota	7.1	4	2	6	0.38	0.05
Ohio	4.0	21	8	29	1.81	0.45
Oregon	9.5	0	0	0	0.00	0.00
Pennsylvania	4.6	17	13	30	1.88	0.41
Rhode Island	0.1	0	0	0	0.00	0.00
South Carolina	3.4	13	3	16	1.00	0.30
South Dakota	2.7	5	21	26	1.62	0.21
Tennessee	4.6	15	10	25	1.56	0.34
Texas	27.4	18	35	53	3.31	0.12
Utah	8.4	0	0	0	0.00	0.00
Vermont	1.0	2	0	2	0.12	0.12
Virginia	0.1	9	2	11	0.69	0.11
Washington	7.0	0	0	0	0.00	0.00
West Virginia	2.3	1	0	1	0.06	0.03
Wisconsin	5.3	11	10	21	1.31	0.25
Wyoming	9.8	1	0	1	0.06	0.01

ELECTRIC TURNING MACHINERY has recently been placed on all the bridges over the main stem of the Chicago River, and the City Engineering Department expects within a few months to similarly equip 20 more bridges on the north and south branches. In speaking of the change, Mr. J. E. Roemheld, engineer of the city bridge department, who designed and has personally directed all the work, says: "We find electricity on bridges more economical in operating expenses, easier to handle, cleaner and in every respect superior to steam." The present steam equipment is, however, retained as a reserve.

THE DISPOSAL OF GARBAGE AND REFUSE.*

The subject upon which your Committee was requested to make a report concerns the collection and disposal of the solid waste matter in cities, such as garbage, ashes, manufacturing refuse, etc. This branch of municipal work had heretofore not received satisfactory attention. There was much diversity of opinion regarding the proper methods to be pursued, and a basis upon which safe judgment could be founded did not as yet appear to exist.

It was, of course, impracticable for your Committee to make any original investigations or experiments to enable it to solve the questions before it. Its work had to be confined to the collection of statistics, the inspection of works and the weighing of the evidence and opinions of those directly engaged in the actual work of garbage and refuse collection and disposal.

In order to gather the needed information, circulars containing numerous questions were prepared and sent to 170 cities of the United States and Canada. The existing literature of the day was examined and visits of inspection were made, as was convenient, to the most important and instructive works of both Europe and America. By classifying, comparing and critically studying the information thus obtained, it became practicable to throw some useful light on the subject and to enable your Committee to reach conclusions.

This information had been practically all compiled last year, and such of the results as were then apparent, were reported at the last annual meeting. It was added then, that in view of certain forthcoming reports on some very thorough experiments, being conducted in the cities of Hamburg and Berlin, your Committee did not deem it proper to present its own final report until after this European information had been obtained. Not until within the last few weeks did the documents reach this country. Their value, in the opinion of your Committee, justifies the delay in concluding its own work, as without embodying these European results, the Committee's report would have failed to record the most complete, instructive and valuable experiments on garbage and refuse destruction for large cities that have yet been published.

The collection and disposal of garbage and refuse must be considered, first, from a sanitary, and secondly, from a financial aspect. Satisfaction must be given in both respects; otherwise, as previously reported, the result will not be successful. "There may be a disposal which is entirely proper in a sanitary way, yet the expense may be so great that the method precludes general adoption. On the other hand, some cheap method of disposal may not comply with sanitary requirements, and can also not be recommended."

The solution of the problem depends upon the character and composition of the matter to be dealt with, upon the quantity to be handled, upon the necessary transportation to the place of disposal, upon the character of organization in charge of the work, and upon the ultimate disposition to be made of the material.

The best method of disposal will vary according to what can or must be done with the material. When it contains matter that may be converted into useful products, its disposition might properly differ from that which is necessary when it must be destroyed in a manner to prevent a nuisance or injury to health. Such utilization, when practicable, must be secondary in importance to a proper sanitary disposition. If the cost of disposal can be reduced by converting a part of the whole of the material into salable products, then utilization may be advocated for financial reasons, but only with the provision that a sanitary danger or nuisance is not created.

The best method of disposal when the quantity of material is small, may also be different from when it is large; it will also depend upon whether it must be transported to a great distance or can be disposed of near the point where it is collected.

The questions of collection and disposal are, therefore, somewhat complex. From the variety of conditions which may govern the case, it will be seen that proper answers can only be given when the special conditions existing in each city or town are known. In the opinion of your Committee no single system of disposal can be recommended as being the best under all conditions.

This conclusion is further supported by the fact that the character of city refuse as collected differs materially in different countries, cities, and even in different parts of the same city. In some communities all refuse, namely, kitchen garbage, ashes and dry refuse from houses, factories, wharves, etc., is put into the same receptacles and delivered at the same point. In others, a separation is maintained of some of the materials, the food waste being collected in a different way and at different times from the dry refuse and ashes. In cities or parts of cities, where no sewerage system exists, the night soil or human excrement is collected in special receptacles, and is disposed of sometimes separately, sometimes together with other refuse matter.

The terms garbage and refuse were defined by the Committee as follows: By garbage is meant animal and vegetable waste matter subject to rapid decay, and collected from kitchens, markets, slaughter houses, etc., but not including night soil or street sweepings. By refuse is meant the miscellaneous material comprising the dry waste matter from houses, stores, factories and streets, such as ashes, paper, straw, wood, rubbish, etc. These definitions are most commonly used throughout the country. In the Southern States, however, the term "garbage" is sometimes applied to dry refuse (Atlanta, Ga.) and to a mixture of dry refuse with animal and vegetable waste. In New England the word "swill" is more commonly used to designate kitchen waste, while in Pennsylvania and one or two other States "slop" is the name applied to it.

The present final report to a certain extent supplements the previous reports, but it contains all the conclusions which have heretofore been stated. The appendix contains the replies to circulars from over 150 American and Canadian cities, which constitutes a valuable mass of information concerning the status of the question in this country. It also contains descriptions of the most important methods of disposal in detail and of receptacles, carts, wagons, etc., which appear to have given fair satisfaction. It finally contains descriptions of the best European practice and the results thereof.

Collection and Removal to Place of Disposal.

The Committee has found that in comparatively few places was there a careful and wise consideration given to the character of utensils, receptacles, carts or wagons in which the refuse and garbage is collected. In most cases these articles are left to the judgment of house occupants or of contractors who collect the material.

No general recommendations can be given with reference to the character of the receptacles and wagons, because they should vary according to local conditions, and with the climate and method of final disposal. In cold countries, for instance, metal receptacles are not advantageous in the winter months, and wooden receptacles are preferred. The reverse is the case in hot climates. In all cases, however, they should be covered with a lid, and where cities give any directions at all with reference to these receptacles, this requirement is usually stated. Suitable cans for different conditions are described in the appendix.

Carts or wagons should be made of special design to suit the special conditions. Whether the garbage and refuse are collected in the same carts and wagons, or whether there is a separate collection, these carts and wagons should be covered. They should be covered with lids that can be easily opened and also firmly closed. They should be constructed of such shape that they can be easily and completely emptied of all their contents. Good designs for this purpose are found in use in some of our cities and are given in the appendix. It may be found economical with certain cases of disposal, to have the carts so constructed that the boxes may be lifted off the wheels for dumping purposes. In some cases it may be found preferable and less expensive to collect the material in large wagons drawn by two horses, while in other cases carts with single horses may be preferred. With the variety of designs that are in use, an intelligent selection of the most suitable design for given cases may be easily made.

Where the garbage is disposed of by dumping at sea, special scows and boats have been constructed for the purpose. The experience in Boston and New York City with such boats has probably developed the most suitable apparatus of this kind. The boats are so constructed that they can not only be readily loaded, but also can discharge the material by a single operation.

The collection of night soil from sections of the city not having sewers is usually accomplished by apparatus known as odorless excavators, and of these also there are several designs in the market which have proved satisfactory. The important features being an air-tight vessel, means of introducing the night soil by pumping through a special hose, and attachments for preventing the escape of noxious gases.

Regarding the frequency of collecting garbage and refuse, there seems to be no uniformity of practice, even in cities similarly situated. In some cases garbage proper is collected daily during the summer months; in most cases, however, but two or three times a week. Often the collection is more frequent in the densely populated portions than in the suburban districts of the city. It is the opinion of your Committee that no difference should be made with reference to the density of population. Readily decomposing material should be removed as soon as possible after it has been offered for collection, as it will become odorous and objectionable equally as soon in the suburbs as in the center of the city. Decomposition is a question of time, not of locality. The frequency of collection should therefore depend on the season. It should, if possible, be collected daily in hot weather, at least three times a week in the spring and fall and not less than twice a week in cold weather.

Ashes and dry refuse may be collected at all times once a week without objection, this being the usual practice. Refuse from business establishments or hotels must, in some cases, be removed more frequently on account of its rapid accumulation.

If garbage is collected daily, no decomposition should take place. Where it is collected less often in warm weather it is recommended that the receptacles, carts, wagons, etc., be disinfected and, if practicable, washed every time after they have been used. When garbage and dry refuse are removed together the frequency of collection should be the same as though it were all garbage.

Character and Composition.

Your Committee has been able to secure but little information on the composition of garbage and refuse in the United States. In English and German cities this material has been frequently analyzed. In this country we have only secured one satisfactory statement, namely, from New York City. The analyses are given in the appendix.

The combined garbage and refuse in Germany differs from that in England by being poorer in combustible matter. English refuse contains more unburnt coal and also more waste organic matter. For this reason the products of combustion weigh but one-third of the original weight in England, and about one-half of the original weight in Germany.

In America, so far as ocular inspection goes, the ashes contain fully as much unburnt coal as in England, and decidedly more than in Germany. The quantity of kitchen garbage and combustible refuse is greater per inhabitant in America than in England, and still greater than in Germany. While the amount of organic matter in American garbage is greater, it is also true that in most cities it contains more moisture. The large quantity of vegetable and fruit refuse in our country probably causes this result.

American kitchen garbage contains from 2 to 4% of grease. European garbage contains somewhat less, i. e., from 1 to 3%. From kitchen garbage about 5% of the original weight is left as ashes after combustion. When American garbage and dry refuse, including ashes, are mixed and burned, about one-fourth of the weight of the original mass remains as clinkers and ashes; in England one-third and in Germany one-half. It is therefore seen that three-fourths of American mixed garbage, two-thirds of the English and only one-half of the German mixed garbage can be burned.

Final Disposal.

The various ways in which garbage and refuse have been finally disposed of in American cities were mentioned in previous reports, and a few conclusions have already been drawn. In reviewing the subject, and with the recent evidence, particularly the above mentioned European reports before it, your Committee can complete and sum up its conclusions as follows:

It has already been said that different conditions require different solutions. In view of this fact, a distinction must first be made as to whether the garbage is to be disposed of by individuals or by the community at large.

(A.) By Individuals.—If each householder must himself dispose of the garbage and refuse, as in the case of a country house or in a village, the following is recommended:

There appears to be no way in which this material can be properly and cheaply disposed of when the garbage is mixed with ashes and other refuse, and it is the opinion that in such cases it should be kept separated. There are several ways in which the most objectionable part, name-

*Report of the Committee of the American Public Health Association on the Disposal of Garbage and Refuse; Rudolph Hering, M. Am. Soc. C. E., Chairman, Woodbridge Building, New York City; presented at the annual meeting of the Association, at Philadelphia, Oct. 29, 1897.

ly, the garbage, can be safely and properly disposed of. When it is fresh, and when nothing of a poisonous nature is added, then it can be safely fed to animals. In country houses this method is common. It is necessary, of course, that such feeding be confined to cases where proper intelligence can be exercised. The garbage from hotels is also very commonly sold for feeding, as it is profitable, and with proper care, no objectionable results need follow. Where this method is not applicable, or where dangerous results are feared, there are but two other methods which your Committee can indorse, namely, cremation and burial. To burn the garbage in the kitchen stove by throwing it upon the coals is often practiced, but is objectionable on account of the offensive odors which arise therefrom. Within a few years means have been provided and are in the market for carbonizing the garbage in the flue leading from the kitchen stove. This process, where applicable, can be well recommended. The garbage is slowly dried, then charred, and finally can be used for fuel, all without the discharge of any odors. Where this carbonizing is not undertaken, the only other safe alternative is a burial of the fresh garbage.

The remaining refuse of a country house consists of ashes, dry rubbish, and perhaps also of night soil. In this case the latter is often converted on the premises into compost or manure and used upon the surrounding grounds. There can be no objection to such a method of disposal, if in case of certain sickness the night soil has been thoroughly disinfected. The disposal of ashes and rubbish will furnish no difficulties in the present case, as they can be dumped at an unobjectionable point on the premises or elsewhere.

(B.) By Communities.—The problem becomes a very different one when garbage and refuse must be collected from many building as in cities, and a common disposal provided. The quantities to be dealt with become large, and the control over the character of the material is lost. Other methods of disposal must, therefore, be resorted to, if sanitary as well as economical results are to be obtained.

In this case it becomes practicable either to combine all the various rejected materials, or to keep them separated. A choice between the two methods will depend upon the local conditions and customs. In many cities, in nearly every European city, the garbage and dry refuse, including ashes, are all mixed, removed and disposed of together. In American cities they are combined in some cases and in others a separation of some of the material is made. Your Committee is not able to state that either one or the other method is to be preferred in all cases. There may be instances where a separation is better, and there may be others where the combined removal offers less difficulties and is less expensive.

(a) Separate Removal.—The fact that domestic garbage contains a fair percentage of grease, and that the remaining material may be converted into a fertilizer, has caused the development of processes in this country for converting garbage into these two materials, to be sold at a profit. Such a method of disposal is applicable only in large cities. The works, which must be erected for this treatment of garbage, can only be profitable if large quantities are handled. Such works have been erected in a number of cities in the United States. Companies were formed, and the work was undertaken with the expectation of conducting a very profitable business. Experience has demonstrated, however, that in many instances there was no profit, and in others that it was small. It has heretofore been found impracticable to conduct the works so that a nuisance would be wholly prevented, and it was, therefore, found best to locate them at points where an occasional nuisance would not be objectionable. After several years operation a number of these works have been abandoned because, under the necessary sanitary restrictions, they were not found to be remunerative.

From a sanitary point of view or as regards the creation of a nuisance, this process of disposing of garbage should be viewed with some suspicion. It should be allowed and, in the opinion of your Committee, is only justifiable when the works are so located that a nuisance cannot possibly be created, and when it is also found to be cheaper to the community than cremation.

Experience has shown that in many cases this reduction process does not dispose of all the offensive material, and that it must be operated in conjunction with the cremation process, because some of the material collected with the garbage will neither yield grease nor make a good fertilizer, and is best disposed of by burning.

The latest and largest works for disposing of garbage by the reduction process, have been built on Barren Island, where the garbage of New York and Brooklyn is being tested. Contracts for this treatment were made within the last year or two, and it appears at the present time that the history of these works may possibly not differ much from the history of others. In this case, however, the distance from inhabited sections and the great quantities of material to be handled, offer more favorable conditions for success than in most other cities. As the selling price of both the grease and the fertilizing residue has been steadily declining, it may probably be safely inferred that the profit of the reduction business does not meet the early expectations.

When the garbage is collected separately from the other refuse, then there remains another method for its disposal, which receives the commendation of your Committee, namely, cremation. When garbage is separately collected it contains from 50 to 80% of moisture. This fact has made its burning difficult. There is insufficient combustible material contained in the same to evaporate the large quantity of moisture contained in fresh garbage while burning up itself. For this reason it has been necessary to add coal to supply the heat in most of the American furnaces. They are nearly all so constructed that the wet material is thrown directly upon the grate-bars. In the English furnaces the garbage and refuse are first thrown into an ante-chamber, where the material is dried before it reaches the grate-bars. Your Committee is not aware of the existence of a furnace constructed after the English pattern where garbage alone, without the addition of rubbish, ashes and cinders has been consumed. It is, therefore, not in a position to state the actual results that would be found if garbage alone were burned in an English furnace. It seems, however, in view of the evidence before the Committee, that it might possibly be found economical to subject garbage to a drying process before it is thrown upon the grate-bars. With moderately wet garbage and suitably arranged apparatus it seems possible that the combustion might be effected with less coal than is now generally used. No intelligent experiments in this direction have, however, come to the attention of your Committee, and no definite statement as to the economy of such a process can be given.

Besides, the reduction of the kitchen garbage to grease and fertilizer, or its cremation, your Committee is not able to designate any proces by which the garbage of communities can be finally disposed of either economically or in a sanitary manner. If the garbage is disposed of separately there results the necessity of a separate disposal of the remaining material, consisting of ashes, cinders, rubbish and dry combustible matter. Ashes and incombustible refuse can be safely wasted or dumped for filling in low ground. Dry combustible matter, of which large cities usually furnish a considerable amount, is best disposed of by being burned in a crematory.

Your Committee feels compelled to state, with reference to the disposal of these materials, that a separation does not seem to be economical or advisable, unless the conversion of garbage into saleable products is an assured profitable business. It has not so been found in the larger cities of Europe, and separation is not there practiced.

(b) Combined Removal.—When no separation is made of the various waste materials and all are collected together, there is, in the opinion of your Committee, but one way in which the final disposal should be accomplished; namely, by cremation. This is the system successfully adopted under these circumstances in many cities of Europe, and is growing in favor every year. (See statistics in appendix.) In England the burning of city garbage and refuse has been practiced in some cities for half a century. Considerable experience has, therefore, been gained regarding the most suitable construction of the furnaces and the manipulation of the material.

Within the last two years extensive experiments have been made in the cities of Hamburg and Berlin on the subject of garbage and refuse cremation, as already stated. The results there obtained with garbage that contains less combustible matter than the English and still less than the American garbage and refuse, indicates without any doubt, that a destruction of this material by fire can be an economical process, besides offering a thoroughly sanitary solution of the garbage question.

The European furnaces have not yet been introduced in America. Within a few years, however, a furnace, resembling the English pattern, but apparently less efficient, has been erected in Montreal. The experience gained with it has been fairly satisfactory. The garbage and ashes are mixed, and they burn without the addition of fuel. It is found necessary, however, as was also found necessary in some cities of Europe, to sift the material and thus to free it from the fine ashes, which choke the fires.

Garbage in America contains more moisture than that in Europe, and this fact has made it appear as though cremating would not be as successful in this country; but your Committee has reason to believe that the additional quantity of combustible material usually contained in the average American garbage more than compensates for this additional moisture, when the dry refuse and garbage are mixed. Without having a proper analysis at our disposal, we may say that to the eye there is no apparent difference in this respect between the mixed garbage and refuse of Europe and that of America.

In view of the results obtained during many years in England and lately obtained also in Germany, as fully given in the appendix to this report, there appears to be no reason why the same method of disposal, under the above mentioned limitations and conditions, should not be applicable to this country, by using properly constructed furnaces and having efficient workmen, thereby effecting a destruction of the material in a more sanitary way and probably also more economically than by other methods that have been tried.

Your Committee finds that the recent report from Hamburg, Zurich, and particularly the one from Berlin, have given material for a better understanding and judgment regarding the cremation of garbage than has been possible since the early English reports on the subject. A final report on similar experiments with similar results recently gained in Paris is also about to be issued.

The experience and results now before your Committee indicate that the English pattern of cell furnaces with sloping ante-chamber for a preliminary drying and heating of the garbage give more economical results than the large and level American furnaces. It also plainly indicates that a skillful construction of the entire plant, and a skillful operation, requiring special training of the firemen, are prime requisites to obtaining successful results.

RAILWAY BRIDGE FLOORS.*

At the present day the open floor is the form of floor generally used for American railway bridges. The use of tight floors has been confined principally to bridges built in or near cities for the purpose of eliminating grade crossings of highways and railways, and the different conditions and legal restrictions governing each particular case have resulted in a great variety of designs. The accompanying illustrations have been selected to illustrate the different types of open bridge floors. The ordinary functions of the floor are to support the track and transfer the load to the main trusses or girders. In addition, the floor should be so designed and built that a derailed car will safely cross the bridge.

The component parts of the floor are the ties, guard timbers and guard rails, stringers and floor beams. The timber guard sticks outside of the rails were first used to prevent derailed wheels from running off the ends of the ties. Mr. John D. Isaacs, of the Southern Pacific Co., writes:

This timber, in case of derailment, without the use of an inside guard rail, becomes an element of danger. If any of the wheels of a derailed truck crowd against the guard timber it is very apt to slew the truck and throw the car overboard.

The same fact is stated in a circular relating to guard rails on bridges, issued by the Massachusetts Railroad Commission. The inside iron guard rail, 8 to 10 ins. clear of the running rail is now generally depended upon to keep derailed wheels on the ties.

The proper use of the guard timber is to act as a spacer for and to prevent bunching of the ties by a derailed wheel. This is accomplished by notching the guard sticks over the ties, and also fastening them to the ties by bolts or lag screws. From 1 to 1½ ins. depth of notch, and a bolt at every fourth tie for fastening has been found to be sufficient. Lag screws for fastening have the advantage over bolts, that they can be used in places where it would be difficult to get at the lower end of a bolt to screw up the nut. Also, they obviate the trouble that arises from the nuts getting loose and falling off. On some wooden bridges the guards, ties and stringers are bolted together with one bolt. The guard timbers are spliced with a scarf joint and one bolt at a tie, or merely butted with bolts in two adjacent ties. The timber should be placed far enough outside of the running rail to be clear of the outside wheels of a derailed truck, when the inner wheels are running against the guard rail. With the guard rail 10 ins. clear of the running rail, this will require at least 6 ft. 10 ins. clear between the guard sticks. The sticks are spaced farther apart than this, generally at or near the ends of the ties, to be out of the way of snow plows.

The rails are supported by, and fastened to, the ties. The clear spacing between the ties has been decreased so that a derailed wheel running over the floor will not drop down between the ties. The spacing now used varies from 4 to 7 ins.; the former being considered objectionable, as being too close. Before the use of inside guard rails the length of tie was increased to 12 ft. to keep wheels on the floor. This necessitated supporting the ties outside of the rails, as derailed wheels would break off the ends. This was accomplished either by the use of outside stringers under the ends of the ties or by increasing the spacing between the track stringers. With the use of proper guard rails the minimum length of tie is governed by the required clear distance between the guard timbers. With sticks 8 ins. wide, the length of ties would be 8 ft. 2 ins. The length of 12 ft. has, however, been adopted, as it enables the guard sticks to be placed clear of everything, furnishes a convenient platform to work on in case of accident, closes the gap between tracks on a double track bridge, is an additional preventative of accident in case the wheel jumps the guard rail, and in case the guard rails are not used the greater width is necessary.

The ends of ties projecting beyond the guard sticks are waste material so far as protection from accident is concerned. When ties are subjected to tranverse stress by placing the stringers outside of the rails, the rails serve to distribute the wheel load over three or more ties so long as

*Abstract of a committee report presented at the Denver convention of the Association of Railway Superintendents of Bridges and Buildings, Oct. 19 to 22, 1897.

the wheels are on the track. The load from a derailed wheel will come practically all on one tie, and unless considerable margin has been allowed in proportioning the tie it will be dangerously overloaded. Heavy timbers placed as near as possible to rails and bolted to every

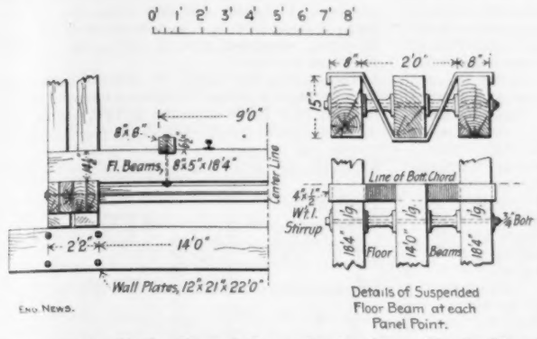


Fig. 1.—Floor for Wooden Through Truss, showing Suspended Cross-Tie at Panel Point.

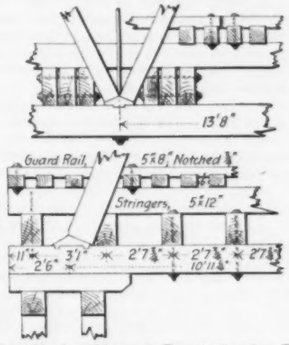


Fig. 2.—Floor for Wooden Through Truss, showing Two Methods of Arranging Floor Beams.

tie are sometimes used to distribute the wheel load over the adjacent ties.

To prevent the ties moving sideways, they are notched over or fastened to the stringers. On wooden bridges it is sufficient to spike the ties to the stringers with ½-in. boat spikes without notching. On iron bridges the ties are notched from ½ to 1 in., and in many cases are fastened to the iron work by bolts through every third or fourth tie. Except in localities where there is danger of the floor being blown off the bridge, there does not appear to be much necessity for these bolts. Unless greater sizes are required, due to the tie acting as beam, an 8-in. face and depth sufficient to hold the spike and allow for notching are all that is necessary, say 6 ins. for ties on wooden bridges, and 7 ins. with ½-in. notch for ties on iron bridges.

Stringers and floor beams are used to support the track and transfer the load to the main girders or trusses. Their arrangement will be seen in the accompanying illustrations of various types of floors.

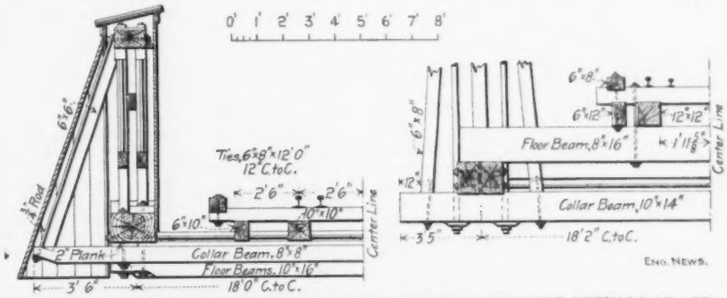
(1) Wooden Stringers.—These bridges are built both with long and short ties. The main stringers are placed directly under the rail and the ends of long ties supported by side stringers. A certain portion of the load depending on the relative stiffness of ties and stringers, is carried by the side stringers. The practice on the B. & M. R. R. is to put six sticks under the track, two under each rail and one each side 10 ft. out to out, and consider the side stringers to carry 20% of the load.

Through Wooden Truss Bridges.—The floor beams are either supported on top of, or are hung below, the bottom chord. The first method furnishes a direct support for the floor beams, but the deflection of the loaded floor beam brings the load on the inner edge of the chord. When the floor beams are hung below the chord, the hanger can be designed to distribute the load over the whole width of the chord. By the latter method, there is also a gain in head room over the rail, equal to depth of chord plus depth of floor beam. Another advantage of suspended floor beams is that they do not have to be cut away at the ends when near a panel point of the truss, to clear the braces.

Fig. 1 is an example of the floor where the ties are used for floor beams. The clear spacing between is 7 ins. At panel points the tie has to be supported from the one each side, as shown on Fig. 1a. The 8×8-in. guard stick is bolted to every tie, and aids in distributing the wheel loads. A bridge with a similar floor, recently taken down on one of the branches of the B. & M. R. R., had a 10×10-in. guard stick bolted to every floor beam, and a 4×4×¾-in. angle iron for an inside guard rail, also bolted to every floor beam. This evidently was more efficient in distributing the loads from a derailed wheel than the example shown. When ties and stringers are used, the floor beams are either spaced uniformly or concentrated at the panel points, both methods being shown by Fig. 2. The latter method reduces the bending in the chord to a minimum, but calls for a larger stringer. By using side stringers and considering them to carry part of the load, the bending moments, and consequently the sizes of the floor beams, will be reduced. With suspended floor beams, the lateral bracing rests on top of the beams, and the stringers are cut on to it. When the floor beams are uniformly distributed, this will not affect the strength of the stringers; but when floor beams are concentrated, it becomes a serious matter.

Wooden Pony Trusses.—The floors for these bridges are similar to those for through trusses. The manner of bracing the top chord is mentioned here, as it is affected somewhat by the design of the floor. The top chord is braced from a collar beam fastened to the bottom chord. When the floor beams rest on top of the chord the collar beam can be bolted below the chord, and is out of the way. When the floor beams are hung below the chord, the collar beam will deflect with the floor, and throw the top chords out of line unless the collar beam is blocked down below the tops of the floor beams, as shown in Fig. 3. In Fig. 3 the collar beam is bolted to the truss independent of the truss rods. This is preferable to the method shown in Fig. 4, as the trusses can be built complete and erected in place, and shrinking or crushing of the collar beam will not affect the adjustment of the truss rods.

Wooden Deck Trusses.—The floor beams rest on top of the top chord, and unless the bridge is roofed over, the arrangements and details are the same as for through bridges. The top of the top chord is protected from the weather by galvanized sheet iron, as shown by Fig. 5.



FIGS. 3 AND 4.—FLOOR FOR WOODEN PONY TRUSS, SHOWING DIFFERENT METHODS OF ATTACHING COLLAR BEAM.

Mr. James McIntyre has charge of some of these bridges and writes:

This construction I do not approve of, on account of the constant springing of the floor tending to weaken the flange angles and flange plates.

The lateral bracing and ties interfere with one another, the ties bearing against and loosening the bracing. Fig. 8 shows the method used to overcome these difficulties. The shelf angle carries the ties and there is plenty of room for the lateral bracing. Floor beams and stringers are introduced to shorten the span of and reduce the size of the tie.

Through Iron Truss Bridges.—Generally there are two stringers to a track spaced from 5 to 8 ft. c. to c. and headed into the floor beams. The details of ties are the same as for deck girders, sizes being governed by spacing of stringers. At the floor beams there is a break in the continuity of the spacing of the ties, caused by the floor beam flange increasing the clear distance between the adjacent ties. This is not a very important matter, as the top of the floor beam is seldom more than 2 or 3

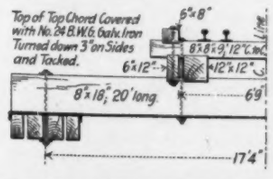


Fig. 5.—Floor for Wooden Deck Truss, showing Method of Protecting Top Chord; Southern Pacific Co.

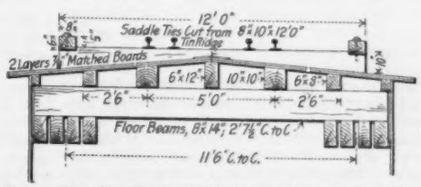


Fig. 6. Floor for Wooden Deck Truss, showing Roof Construction; Boston & Maine R. R.

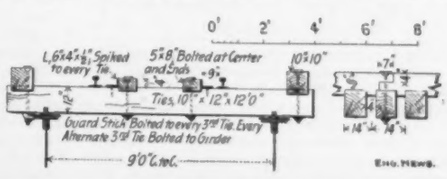

0' 2' 4' 6' 8'
L, 6"x4"x⅝" Spiked to every Tie.
5"x8" Bolted at Center and Ends
9"
10"x10"
Ties, 10" x 12"x 12'0"
Guard Stick Bolted to every 3rd Tie. Every Alternate 3rd Tie Bolted to Girder
9'0" C. to C.
14"
14"
ENG. NEWS.

Fig. 7.—Floor for Deck Plate Girder, showing Chord Construction to Prevent Side Movement of Ties; Chicago, Milwaukee & St. Paul Ry.

With a record of service of from 40 to 50 years for wooden truss railway bridges, when properly designed and protected from the weather, it would appear to be economy to cover all wooden truss bridges. This does not affect the floor for through or pony trusses, but the roof for a deck bridge makes a change in the design of floor necessary.

There are several different ways of putting a roof on a deck bridge. The example shown by Fig. 6 is the standard of the Boston & Maine R. R., and is to be recommended as protecting everything except the ties and guard sticks from the weather.

Rolled Beam Bridges.—The arrangement of ties and spacing of stringers differ but little from wooden stringer bridges. Side stringers, when used, cannot be figured as carrying any of the load when wheels are on the rails, owing to the greater rigidity of track stringers compared with the ties.

Deck Plate Girders.—The usual method of construction is to place two girders under each track, the girders being spaced from 6½ to 9 ft. on senters, the spacing being governed to some extent by length of span and depth of girder. In the ordinary form of construction, the ties act as floor beams and deflecting under a load bring the reaction along the inner edge of the top flange, tending to bend it down. Fig. 7 shows a method of concentrating the load at the center of the flange, and preventing side movement of the ties without the necessity of notching them out the full width of the flange. The top lateral bracing in this style of bridge should be designed so that there will be no interference with the ties.

The standard deck girder of the Boston & Maine R. R. differs from the foregoing by the addition of floor beams and stringers. The stringers support the tie under the rails, and the girders, spaced 9 ft. c. to c., act as side stringers for supporting the ends of ties in addition to their regular duties. There is one system of longitudinal bracing in the plane of bottom flange of floor beams. The bridges are riveted up complete in the shop, transported to the site, and put in place at a minimum cost for erection. Ties of minimum thickness are also used.

Through Plate Girders.—In the simplest floor the ties act as floor beams and are supported by the bottom flange

ins. below the top of the tie, and a derailed wheel would go over all right and the wide space does not make a noticeable difference in riding of the track. The clear distance of 14 to 15 ft. between trusses of through bridges is more than ample to keep clear of a derailed car when it is kept in place by the guard rails and has been adopted with reference to the safety of brakemen on the sides of cars. The State of Vermont requires a clearance of 15 ft. for this purpose. When the tops of through girders extend above the level of a car floor they should be built with the

same clearance, but shallower girders can be placed nearer the rails.

Iron Deck Trusses.—Commonly the ties are used as floor beams, the details being similar to those for deck girders. Fig. 9 is an example of iron floors with the floor beams riveted to the posts, the top chords acting as side stringers. The lateral bracing is both in the plane of the bottom flange of the chord and of top flange of floor beam.

Skew Bridges.—The simplest arrangement for deck bridges is to lay the bridge ties parallel to the parapets, and fan out the grade ties. The bridge ties do not receive their load at the same time, and tend to jump and wear out more rapidly. The grade ties are either too far apart under one rail or so close together under the other that it is difficult to tamp them. Fig. 10 shows a method of keeping the bridge ties square to the track. The Union Pacific Ry. treats the end grade ties in the same manner. One objection to this method is the short lengths of ties supporting sometimes only one rail and tending to work loose. There is always somewhat of a jar when the train passes from the ballast road-bed to the more rigid bridge floor, and unless both wheels of an axle pass onto the bridge floor at the same time there is a noticeable lurch. The best remedy for this is to square up the end of the bridge floor. For skew trestles the end bents can easily be built square. One way of squaring the floor is to have a longitudinal sill on the bank supporting the other ends of the ties which rest on one stringer only. This is objectionable, as the sill will rot and settle, and it is something that is neither bridge floor nor track, and is liable to be neglected. The best way is to square up the ends of the stringers so that the first bridge tie is wholly on the bridge and the first grade tie is wholly in the ballast.

In concluding their report, your committee make the following recommendations: (1) Ties 12 ft. long, spaced 6 ins. apart in the clear, supported directly under the rails and near the ends; (2) suitable inside guard rails and spacers at ends of tie; (3) squaring the floors at the ends of skew bridges; (4) connecting bridge floor with approach by the method shown by Fig. 11; (5) making the floor independent for each of the two tracks of a double-track bridge.

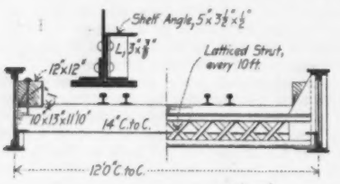


Fig. 8.—Floor for Through Plate Girder, showing Shelf Angle Supports for Cross-Ties; Nashua & Acton Ry.

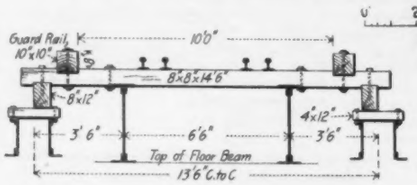


Fig. 9.—Floor for Metal Deck Truss, showing Top Chords Acting as Side Stringers; Manchester & North Weare R. R.

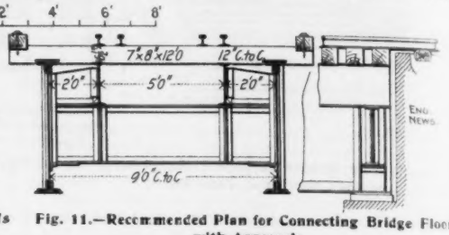


Fig. 11.—Recommended Plan for Connecting Bridge Floor with Approach.

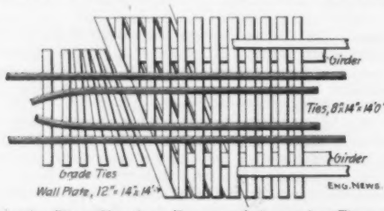


Fig. 10.—Plan Showing Manner of Arranging Ties on a Skew Bridge; Wabash R. R.

ANNUAL MEETING OF THE AMERICAN PUBLIC HEALTH ASSOCIATION.

The twenty fifth annual meeting of the American Public Health Association was held at Philadelphia, Oct. 26 to 29, inclusive. Scores of papers and committee reports were presented, dealing with a wide range of subjects related to the public health. Nearly all the contagious and infectious diseases which occur in North America were touched upon, especial attention being given to yellow fever and to tuberculosis in both man and beast. Even the hygienic phases of barber shops were not overlooked in the attempt of the association to throw light into every dark corner where disease sometimes awaits a victim. Of the many papers presented we shall refer briefly to the important features in some of those most closely related to sanitary engineering.

One of the first reports submitted was that of the Committee on Car Sanitation, written by Prof. S. H. Woodbridge, of the Massachusetts Institute of Technology, Boston. The conclusion of the report suggested that legislative advancement in this matter must be along interstate lines, and that a beginning could best be made by having the subject taken up vigorously by some strong railway corporation.

For the Committee on the Pollution of Water Supplies the Chairman, Deputy Surgeon-General Charles Smart, U. S. A., submitted, but did not read, a report understood to be devoted to standards for bacteriological investigations of water supplies. Three years had been consumed in reaching an agreement on bacteriological standards. The committee was of the opinion that the association should not undertake to supervise a bacteriological examination of water supplies, as had been suggested, the amount of work involved rendering it unlikely that the necessary co-operation could be secured from a sufficient number of bacteriologists.

A paper "On the City of Mexico After the Drainage of the Valley, and the Sanitation Work" was read by Dr. Roque Macouzet. It gave meteorological figures, mostly averages, for the past 15 years, and described the drainage works (see Engineering News, June 14, 1894) and sewerage system of the valley and city. A canal will bring in water for the thorough flushing of the sewers.

Much interest was shown in the subject of formaldehyde gas as a disinfectant. This subject was introduced by Mr. Franklin C. Robinson, Professor of Chemistry in Bowdoin College, Brunswick, Me., who made a report as chairman of the Committee on Disinfectants. Formaldehyde in its simplest form, Professor Robinson said, is a colorless gas with a pungent odor, and having an irritating effect on the mucous membranes. Its formula is C H_2 O. It has marked antiseptic and germicidal powers. It does not destroy the higher forms of life, does not injure cotton, silk or woolen fibers and has no effect on coloring matters, except some of the little used analine dyes. Theoretically 93%, by weight, of pure wood alcohol may be converted into formaldehyde, or probably less than 75% of the commercial article. The report by Professor Robinson and several papers following it seemed to show very conclusively that while formaldehyde promises to be a valuable disinfectant, and perhaps by all odds the best discovered, it is as yet in its experimental stage. Most of those who discussed the subject, either in papers or orally, recounted bacteriological tests in which it was shown either that complete sterilization was not effected by the gas, or that a longer time was required to effect that end than the manufacturers had named in the directions accompanying the apparatus.

Just before the close of the session of Wednesday morning an address "On the Relation of Women's Health Protective Associations to the Public Health" was made by Mrs. John H. Scribner, President of the Woman's Health Protective Association of Philadelphia. Mrs. Scribner called attention to the work done by her association in connection with the agitation for the improvement of the water supply of Philadelphia and other features of municipal work. At the conclusion of her remarks adjournment was made to a lunch tendered by the association so ably represented by Mrs. Scribner.

Part of Thursday afternoon was devoted to water and sewage purification. Dr. F. E. Stewart, of East Orange, N. J., described the use of polarite for water and sewage filtration. The system has been practiced for some years in England, and attempts are being made to introduce it here. Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., of New York city, called attention to the fact that he tried polarite as a filtering material experimentally in this country in 1890, and found it would do just what sand will do and no more.

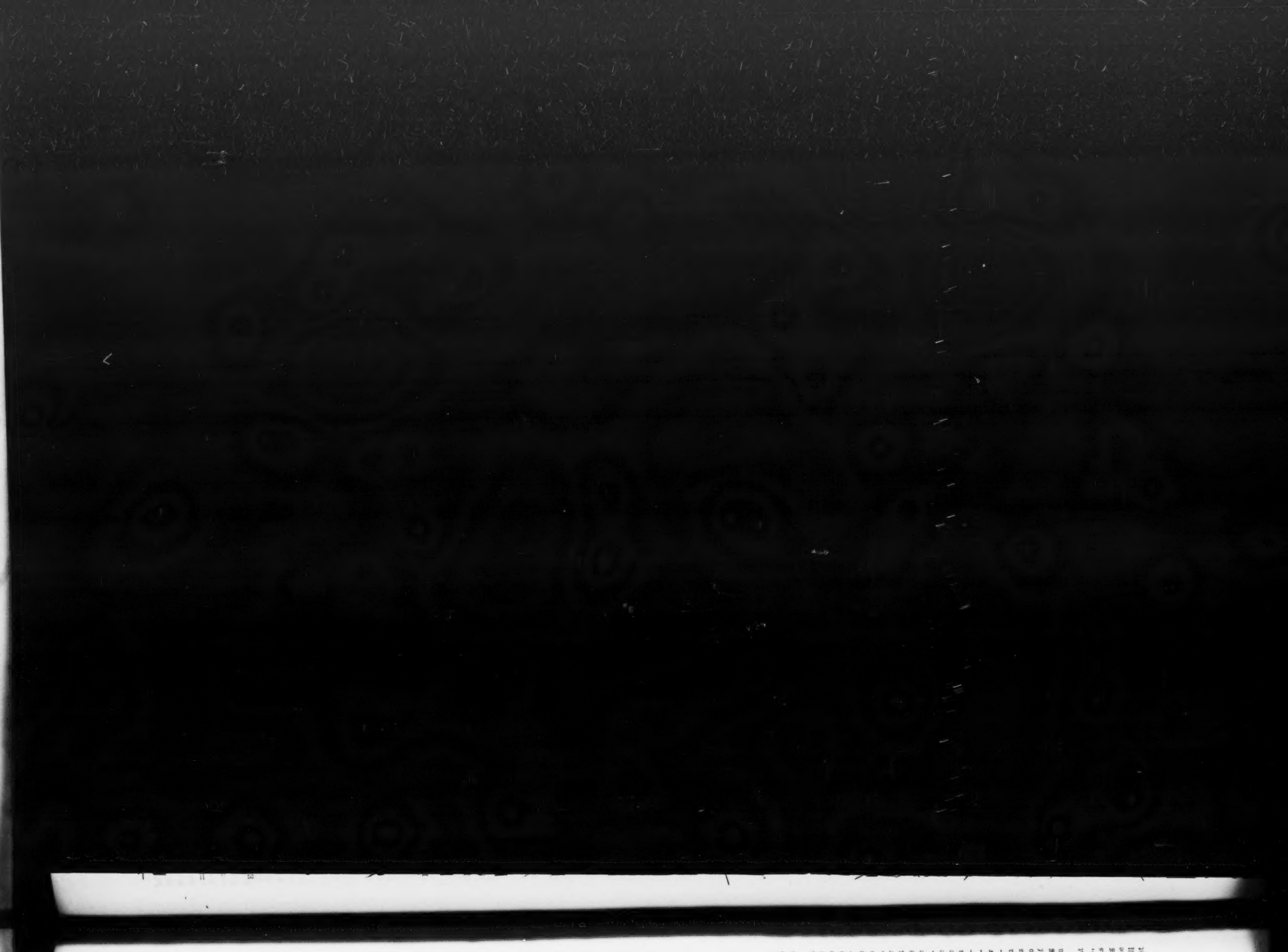
A paper with the title "From Sewage to Drinking Water; A Study of the Natural Processes of Sewage Purification and of the Means Whereby Their Efficiency Can be Increased" was read by Col. Geo. E. Waring, Jr., of New York city. It was a description of Col. Waring's experiments at Newport, in 1894, on forced aeration, combined with screening and intermittent filtration, and of a small plant of the same sort recently built by him at the pleasure grounds in Philadelphia known as Willow Grove Park (see Engineering News, March 11, 1897, for description of the amusement features of this park). Col. Waring claims that with this system one acre of ground can be made to care for a population of 50,000 people. The plant at Willow Grove Park receives some 80,000 to 100,000 gallons of sewage per day and covers about one-eighth of an acre. The sewage first comes to a receiving well of 12,000 gallons capacity, in which there are two screens. It next passes through a coarse filtering or straining material. These processes of deposition, screening and straining are designed to remove the suspended matter, while the final filtration, combined with forced aeration, removes the organic matter in solution. The filtering material in the final tanks, or beds, is 5 ft. in depth, and the sewage is about one hour in passing through it. Bacterial oxidation is the aim of the process. The effluent goes to a small lake, from which it is pumped to a tank and distributed for street sprinkling, closet flushing and other similar purposes. The plant was put in operation on May 31, 1897. A small plant is to be built for about 300 houses in Brooklyn, connected with a real estate development known as Homewood.

In discussing this paper, Mr. Allen Hazen referred to the experiments on forced aeration made by the Massachusetts State Board of Health in 1889, and described in the report of the Board for 1890. It was decided that the process was too expensive to be practicable. Since then Mr. Hazen said he had made plans and secured estimates for treating sewage by forced aeration and filtration. He found that an intermittent filtration system could be built for less money, and accordingly one was constructed.

The water filtration plant of the city of Lawrence, Mass., was discussed in a paper presented by Mr. H. W. Clark, Chemist-in-Charge of the Lawrence Experiment Station. The filter beds were described in detail in Engineering News of Aug. 3, 1893. Mr. Clark stated that the average bacterial removal by these filter beds in 1896 was over 99%. The typhoid death rate in Lawrence for the ten years before the introduction of the filters was 12.36 per 10,000 population, while for the three years and six months since it has been but 2.95, a reduction of 76%.

A paper "On Investigations of Water Supply by the U. S. Geological Survey," by F. H. Newell, Hydrographer of the Survey, outlined the work in hand and touched upon its relations to the problems before the association. Mention was made of stream pollution as an interstate problem.

From an engineering standpoint, by far the most important committee report submitted during the convention was that of the Committee on the Disposal of Garbage and Refuse, of which Mr. Rudolph Hering, M. Am. Soc. C. E., of New York city, was chairman. This committee, or more properly the chairman, has collected a vast mass of information regarding both American and European practice in garbage disposal. Only the conclusions drawn from the report were read by Mr. Hering. These are given, in substance, elsewhere in this issue.

In discussing Mr. Hering's reports Mrs. Scribner thought that not enough stress had been laid upon the value of the reduction process of garbage disposal. She said that when cremation alone was practiced in Philadelphia the collection by the garbage contractors was not satisfactory, but with reduction the collection had been better, because salable products resulted from this process. She also thought that garbage disposal plants should be in the hands of the city, so that if any profit results the city may have it. Mr. Crosby Gray, of Pittsburg, stated that some two years ago a garbage reduction system was put in operation in that city (see Engineering News, Oct. 3, 1895). During the first year the plant proved to be very objectionable, but improvements have been made so that during the past year, or less, the offensive odors from the process and the product had been greatly reduced. He thought they would soon be entirely obliterated. Mr. Gardner T. Swartz, Secretary of the Rhode Island State Board of Health, thought none of the systems yet in use in this country were satisfactory unless prohibitory in cost. Dr. Ernest Wende, Health Commissioner of Providence, stated that the Arnold system of garbage reduction had been in use there for five years and is now giving satisfaction. In closing the discussion, Mr. Hering stated that the committee does not wish to condemn reduction. It has no objection to the process where it is not a nuisance and the cost is not prohibitory. He also called attention to the fact that reduction disposes of only part of the refuse of a city. The cost of handling the balance should be added to the cost of reduction when comparing this with cremation.

The next meeting of the association will be held at Ottawa. Dr. Chas. A. Lindsley, of New Haven, Conn., Secretary of the Connecticut State Board of Health, was elected President of the association for the ensuing year. Dr. C. O. Probst, of Columbus, O., Secretary of the State Board of Health of Ohio, was elected Secretary to fill the unexpired term of Dr. Irving H. Watson, who has just resigned, after filling the office for many years.